DOCUMENT RESUME

ED 247 092 SE 044 688

AUTHOR	Raizada, Karun Shanker
TITLE	Pedagogic Consensuality, Consensibility, and Commensurability in Chemistry Teaching.
PUB DATE	Sep 83
NOTE	149p.; Master of Science Thesis, University of Calgary.
PUB TYPE	Reports - Research/Technical (143) -- Dissertations/Theses - Master Theses (042)
EDRS PRICE	MF01/PC06 Plus Postage.
DESCRIPTORS	*Chemistry; *Classroom Communication; High Schools; Science Education; *Science Instruction; *Secondary School Science; Teacher Education; *Verbal Communication
IDENTIFIERS	Canada; Science Education Research

ABSTRACT

This study examines chemistry instruction from a perspective based primarily on John Ziman's communal knowledge model for science. Several grade 10, 11, and 12 chemistry lessons by three different teachers at three different schools were observed and audiotaped. Data were examined to demonstrate the occurrence of certain specific pedagogic tactics embodied in some metacommunicative teacher utterances within the chemistry classroom teaching/learning discourse. These tactics reflect teachers' concerns for: (1) consensuality of their discourse; (2) consensibility of their teaching utterances; (3) commonality of the frame of reference with their students; and (4) the commensurability of the subject of their teaching discourse with course requirements, curricular structure, and nature of the discipline. In addition, the study relates these four tactics to four analogous pedagogic concerns on the part of a teacher. In turn, these are developed as four constructs for use by researchers or practitioners in recasting the original "pedagogic problematic," namely, the difficulty many students experience in learning chemistry. The problem is reinterpreted from the point of view of pedagogic consensuality, consensibility, commonality of frame of reference, and commensurability. The nature of these findings is discussed, and their implications for practice and as a new focus for teacher education are outlined. (Author/JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED247092

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

THE UNIVERSITY OF CALGARY

PEDAGOGIC CONSENSUALITY, CONSENSIBILITY, AND COMMENSURABILITY IN CHEMISTRY TEACHING

by

KARUN SHANKER RAIZADA

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF CURRICULUM AND INSTRUCTION

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Douglas A. Roberts
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

CALGARY, ALBERTA
SEPTEMBER, 1983

© Karun S. Raizada 1983

SE044688

THE UNIVERSITY OF CALGARY

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "Pedagogic Consensuality, Consensibility, and Commensurability in Chemistry Teaching" submitted by Karun Shanker Raizada in partial fulfillment of the requirements for the degree of Master of Science.

Douglas A. Roberts

Supervisor, Dr. D. Roberts
Department of Curriculum and
Instruction

M Hunsberger

Dr. M. Hunsberger
Department of Curriculum and
Instruction

Dr. R. Heyman
Department of Educational Policy
and Administrative Studies

Ann Kerr

Dr. K. Ann Kerr
Department of Physics and
Chemistry

(DATE) 1983-09-30

ABSTRACT

In recognition of the continuing reputation of chemistry as a difficult subject for secondary school students to learn, this study examines chemistry classroom teaching from a fresh perspective based primarily on John Ziman's communal knowledge model for science. The focal questions addressed in the study concern a teacher's self-monitoring of teaching discourse for clarity of utterances, concordance of teaching and learning, and accordance of the discourse with course requirements, curricular structure, and nature of the discipline.

Classroom pedagogic discourse is viewed as a verbal communicative system consisting of teacher, students, and subject matter. Those elements are seen in a dynamic triadic relationship with asymmetric power distribution, such that the onus to initiate, sustain, and guide the discourse towards its desired objectives rests with the teacher. The methodological approach employed in the study involves exploration of 'natural' chemistry teaching discourse, and requires assignment of meanings and purposes to various utterances within the total context of the discourse.

Several Grade Ten, Eleven, and Twelve chemistry lessons by three different teachers at three different schools were observed and audio-taped. (Chemistry is taught at all three of those grade levels in Alberta.) Selected portions of the work of all three teachers were analyzed in developing the argument of the study.

The study identifies four pedagogic tactics that are 'metacommunicative'--i.e., that communicate about communicating. These are shown to manifest themselves through various teacher utterances that are interpreted within the 'contextual gestalt' of a discourse. They are labelled the *Consensuality Check*, the *Consensibility Check*, the *Frame Check*, and the *Commensurability Check*, and are recognized to serve the purpose of feedback for modification of teaching to make it *become possible* for students to learn what is being taught.

Further, the study relates those four teaching tactics to four analogous 'pedagogic concerns' on the part of a teacher. In turn, these are developed as four constructs for use by researchers or practitioners in recasting the original 'pedagogic problematic'--namely, the difficulty many students experience in learning chemistry. That problem is reinterpreted from the point of view of *pedagogic consensuality*, *consensibility*, *commonality of frame of reference*, and *commensurability*.

The nature of these findings is discussed, and their implications for practice and as a new focus for teacher education are outlined. Some interesting questions for research as extensions of the study are suggested as well.

ACKNOWLEDGEMENTS

The investigator would like to acknowledge the debt of gratitude to the three teachers who so very willingly allowed the observation and audiotaping of their lessons, and who, in accordance with the commitment made to them, unfortunately, must remain anonymous. Grateful thanks are offered to Dr. Douglas Roberts in appreciation of his critical comments and valuable guidance through all stages of the study. Sincere thanks are also extended to Dr. Stanley Norris for his encouragement and friendly support. Last but not least deep appreciations are expressed for the patience displayed by the investigator's wife, Lucille, and daughters, Elaine, Joanne, and Lynn throughout the duration of the study.

TABLE OF CONTENTS

Page

ABSTRACT iii

ACKNOWLEDGEMENTS v

CHAPTER

ONE Focus of the Study 1

- Justification for the Study 2
  - The 'Difficult' Reputation of Chemistry 2
  - Is the Difficulty Well Understood? 3
  - The Importance of Teacher Utterances 5
- Conceptual Orientation 7
  - Focus and Task for the Study 7
  - Philosophical Viewpoint 8
  - Teaching as it Occurs 9
- Methodological Considerations 10
  - The 'Grounding' of the Methodology 10
  - The Importance of Contextual Gestalt 11
  - The Form of Generalization 13
- Significance of the Study 14
- Limitations of the Study 15

TWO Related Research 17

- Introduction 17
- Search Procedures 18
  - Criteria for 'Relatedness' 18

Page

Literature Search 18

Categories of Related Research 20

Analysis of Related Research 21

Research on Chemistry Teaching 21

Research on (Science) Teaching Process 26

Research on Science Classroom Teaching as a Communicative Process 35

Summary 39

THREE Theoretical Perspectives 42

Classroom Teaching as a Communicative Process within Classroom Teaching/Learning as a Communicative System 43

Classroom Teaching as a Communicative Process 43

Teaching/Learning: A Triadic Communicative System . 45

The Metapurpose in Teaching as a Communicative Process 46

Classroom Teaching/Learning as Unique "Unequal-Power Discourse" 48

Pedagogic Tactics, Metapurpose and the Upshot 50

Monitoring for Control versus Monitoring for Modification 51

Importance of Metacommunication in Teaching Discourse 52

Consensuality, Consensibility, Commonality of Frame of Reference and Commensurability 53

Consensuality and Consensibility in Teaching Discourse 53

Commonality of Frame of Reference in Teaching Discourse 55

Commensurability of Teaching Discourse 56

Page

Summary: Emergent Analytic and Methodological Orientations 56
  Viewpoint for Analyzing the Discourse 56
  The Methodological Orientation 57
FOUR Analysis of Chemistry Classroom Teaching 59
  Procurement of Discourse Data 59
  Objectives and Methodological Considerations for the Analysis and the Format of its Description 62
    Objectives for Analysis 62
    Methodological Considerations for the Analysis . . . 63
    The Report Format 64
  The Analysis 65
    Introduction: Metacommunicative Utterances 65
    Consensuality Check 68
    Consensibility Check 91
    Commonality of Frame of Reference: Frame Check . . . 104
    Commensurability Check 109
  Conclusions from The Analysis 118
FIVE Conclusion 123
  Some Salient Features 123
    A Fruitful Area for Research 123
    Methodological Comments 124
  Discussion of Findings 125
    The Findings 125
    Nature of Findings 126

Page

Justification of Findings 127

Implications of the Findings 129

Teaching and the Problem of 'Difficulty' 129

A New Focus for Teacher Education 130

Some Questions for Research 130

REFERENCES 132

CHAPTER ONE

Focus of the Study

The starting point for this study is the widely acknowledged reputation of chemistry as an unusually difficult subject for secondary school students to learn. The difficulty is not well understood, and the investigator's contention is that a fresh approach to the study of teaching events in chemistry classrooms is therefore needed.

For its conceptual framework the study draws primarily on some very promising concepts advanced by John Ziman in his continuing attempts to characterize communication and discourse as these function in the development of scientific knowledge. The "fresh approach" to the study of classroom events in chemistry teaching, then, is to use some of Ziman's concepts as a lens with which to examine the joint development of knowledge about chemistry by teacher and students. Clearly, that approach entails analysis of classroom discourse, and indeed the work of three chemistry teachers at three different schools has been examined.

This document is presented in five chapters. In the remainder of Chapter One, the concerns giving rise to the study are documented, the choice of conceptual orientation and methodology is justified, and the significance and limitations of the study are set forth. Chapter Two demonstrates the uniqueness of the study by placing it against a background of related research. In Chapter Three the general theoretical framework is presented. Interpretive and methodological conceptions, which the investigator uses as an initial orientation to analyzing the data, are delineated and explained. Chapter Four is a report of the analysis and findings, showing the reflexive interaction between the classroom data and the analytic orientation as crystallized in Chapter Three. Finally, in Chapter Five the study is reviewed and the findings and their implications are discussed.

Justification for the Study

The 'Difficult' Reputation of Chemistry

The present investigation had its origin in a dilemma that chemistry teachers, including this investigator, face daily as they go about teaching chemistry to their students. How does one maintain the integrity of the discipline, curriculum and course of studies being taught, and also attend to the legitimate concern of otherwise intellectually able students in the class who find the study of chemistry a difficult endeavour? Surely this dilemma is faced by teachers in all subject areas, but in chemistry it appears to have generated a lot of frustration lately. For example, consider the following excerpt from a recent editorial comment in Chemical and Engineering News:

> Why Johnny can't do chemistry is perplexing to chemical educators. As one professor describes the situation: "These are the students who when enrolled in a science course simply never grasp what is going on. They are not stupid, nor lazy, nor hostile; they really try, but their experience is a prolonged frustration for them and their instructors alike."
> (C. & E. News, April, 1977, pp. 25-26)

Comments such as these by several "master chemistry teachers" led a past editor of the Journal of Chemical Education to note that "the striking thing about this perception of diminishing effectiveness in their ability to get the material across" is that the frustration is expressed by "persons who have distinguished records in teaching chemistry . . .". He goes on to point out that "chemistry has always been difficult for many" but that "during the 70s, the chemistry courses [in secondary school] have become more difficult than courses in other disciplines at the same level . . ." (Lippincott, 1977, p. 331).

The recognition that "For many, chemistry is seen as a difficult, remote subject" (Lippincott, 1979, p. 1) is echoed in systematic findings of a survey of science education in nineteen countries. Evidence was found that "students performed relatively poorly on chemistry items compared with other [science] subject areas"--earth science, biology and physics (Comber and Keeves, 1973, p. 135). This investigator agrees that there is "conclusive evidence that physical sciences are among the most difficult subjects and youngsters acknowledge this 'difficult' reputation" (Whitfield, 1979, pp. 416-7).

Is the Difficulty Well Understood?

Whitfield grants that "a fairly complex picture is emerging with regard to the attitudes and choices of science subjects by secondary pupils" (1979, p. 418). Yet, this investigator contends there is ample evidence that the difficulty of physical sciences in general and chemistry in particular is not well understood. The phenomenon continues to attract attention as a major point of concern for students, teachers and educational researchers.

For example, while calling attention to "the 15 year decline of pre-college science and mathematics education" in the United States, the present editor of the Journal of Chemical Education cited statistics of declining course enrollment from reports of "the recent National Academy of Sciences Convocation on this subject" and identified the "content of science courses" as one of the areas to be addressed for a possible solution (Lagowski, 1982, p. 625). He is seeing 'difficulty' as the basis for student choice not to enroll, and is pointing at course content as the source of student difficulty (rather than, say, the way the courses are taught).

Again, in a recent exhaustive review of trends in research in chemical education, Kornhauser pointed to the 'difficult' reputation of chemistry as one of the reasons intensive research is needed in chemical education. She put it thus: "Fundamental concepts and theories in chemistry have become increasingly abstract and less understood by the majority" (1979, p. 21). This, too, is a hunch about the content of chemistry courses as an explanation for the 'difficulty' students experience.

Whitfield reinforced the same hunch. In summarizing a critical analysis of "resistance to continuing science studies . . . in secondary school" he recommended "further curriculum innovation . . . which builds upon what we know about difficulty levels and preferences." But he then turned his attention to an analysis of research into "the activities and dispositions of the teacher, whom many will assert, despite ambiguous research data, to be both the key and the core to the instructional process" (1979, p. 421). That is a different kind of explanation for student difficulty, of course. Kornhauser commented on it as well. She found in her review (1979, p. 25)

> only a few studies undertaken on student-student interactions. A few critical analyses have been carried [sic] on team-work in education: team-work of students, of students and teachers, and team teaching . . .

but no studies were found on the process of chemistry teaching. She concluded that most research in chemical education "has been and still is applied and developmental in character" and she judged the results of chemical education research for genuinely improving the practice of chemical education to be "relatively sterile" (pp. 38-39).

The 'difficult' reputation of chemistry seems to be widely acknowledged, then, consistent with this investigator's experience. But our understanding of the phenomenon is inadequate, and commentators seem to point in equal measure at course content and teaching as appropriate areas in which to search for deeper understanding. The present study is concerned with a fresh perspective on the process of chemistry teaching, for reasons to be set forth in the next section.

The Importance of Teacher Utterances

To be sure, students may find the study of a subject matter difficult for a variety of reasons. However, this investigator contends that all other factors being equal (!), if the classroom utterances by teachers are made conceptually clear to the students, the degree of difficulty would be reduced substantially.

Much is entailed in the definition of 'conceptually clear', of course. But for the moment consider, in support of concentrating on teacher utterances, that interaction analysis studies ascribe the vast majority of the talk in science classes to teachers. "In almost every study, it has been found that the teacher dominates classroom discussion, talking most of the time (70% - 90%), initiating most interactions (80% - 95%), asking most of the questions (90% - 95%) and reserving sole right to evaluate student responses and comments" (Power, 1977, p. 6; see also Tamir, 1981, p. 99).

It seems a common-sense notion that researchers and teachers would concentrate on the clarity of teacher utterances, especially in science classrooms, where students are introduced to a new language. Attention to the clarity of language is surely one of "the basic precepts of good teaching," as one writer has put it.

> It's hard to learn something that is taught in a
> language you don't understand, or when new words or
> ideas are defined in terms of other new words or
> ideas or in words that have a variety of meanings.
> (Grotz, 1979, p. 7)

The importance of teacher clarity has been emphasized by other researchers as well. For example, in a review of eleven correlational 'process-product' studies, Rosenshine and Furst (1971, p. 44) identified cognitive clarity of a teacher's presentation as one of the most significant teacher process variables, and cited seven studies involving this variable from the period 1963 to 1971.

The extent of teacher dominance of classroom discourse, the central role of language in teaching, and the importance of clarity in a teacher's presentation all point to chemistry classroom teaching utterances as a fruitful area to explore, in order to understand the 'difficult' reputation of chemistry courses.

Conceptual Orientation

Focus and Task for the Study

Much is entailed in the definition of 'conceptual clarity', and researchers use different descriptions of clarity in their investigations of clarity-of-a-teacher's-presentation. In this study, 'clarity' refers not to teaching discourse itself but to a vague criterion chemistry teachers use in self-monitoring of the ongoing process of classroom teaching. John Ziman, in developing his communal knowledge model for science, employs some useful concepts which can be utilized for understanding what it means for a science teacher to 'self-monitor' (as elaborated in Chapter Three). For the present, the focal questions for the study as informed by Ziman's work are given below.

1. How do chemistry teachers assure themselves about the unambiguity and clarity of their teaching utterances? This question is based on Ziman's concept of "consensibility".
2. How do chemistry teachers ensure that the content of their teaching discourse is in accordance with the nature of the discipline, structure of the curriculum, and course requirements? This refers to "commensurability", in the present study.
3. How do chemistry teachers assure themselves while teaching that what is being learnt is, in fact, what they are attempting to teach? This corresponds to Ziman's concept of "consensuality".

These questions place the focus of this study on certain specific teaching utterances. They also delineate the task of the study, which is to demonstrate, in the ongoing process of a classroom teaching/

learning discourse, the form(s) and function(s) of those metacommunicative utterances that teachers employ to monitor their teaching/learning discourse for the kind of qualities implied in the three focal questions.

The definition of the task of the study within the perspectives of the focal questions not only points toward an appropriate methodology, but also requires that a choice be made for a philosophical viewpoint for the study. These considerations are attended to in the rest of this section on conceptual orientation.

Philosophical Viewpoint

While attempting to develop an appropriate theoretical perspective for this study, one of the most important considerations was to keep the significance of the problem uppermost, thereby avoiding its distortion to make it fit currently fashionable methodology. In this regard this investigator was mainly guided by a seminal paper on science education research by Roberts and Russell (1975). These researchers commented that "typical research paradigms" in science education have become "increasingly tired and tiresome" and have ceased to yield useful results (p. 107). They suggested that when research fails to influence practice, more specifically, when science education research fails to improve science teaching and learning, then new "theoretical perspectives need to be developed in order to achieve systematically analyzed science education phenomena" (p. 112). Furthermore, "selection of a basis for developing theoretical perspectives appropriate to science education research must be guided by a demonstrable linkage to issues of everyday science education practice" (p. 112). The "relevance to practice of the theoretical perspectives developed from whatever source" (p. 115, emphasis added) can never be overemphasized.

The phrase "from whatever source" opens up a way to viewing educational phenomena in general and science education phenomena in particular through interdisciplinary perspectives--through a multiparadigmatic approach, or what Rist would call a multifocal lens (1977, p. 47).

In keeping with such a philosophical viewpoint for the investigation of science education phenomena, the present study relies on a number of disciplines for its theoretical orientation and methodological guidance. The eclectic nature of these two elements of the study becomes evident through various considerations in the rest of this chapter, which are presented in detail in Chapter Three.

Teaching as it Occurs

The approach to the problem of science teaching in this study is grounded in another basic premise: one should look at teaching as it takes place, rather than as it might happen, or as it is proposed to occur, or for that matter as it is reflected in student results. Teaching is certainly one of the most significant variables in classroom learning by students. Student achievement on the other hand, is influenced by several factors. Therefore, this investigation regards the study of teaching on the basis of inferences from student results as inappropriate. This contention is consistent with Power's comment (1977, p. 16) based on a critical review of science classroom research: "It is difficult to make unequivocal statements about the relationships among antecedent process and outcome variables in science classrooms."

Similarly, "Accuracy of teacher reports of their classroom behaviors" continues to be "a persistent question for those studying teaching" (Hook and Rosenshine, 1979, p. 1). In an extensive review of studies focussing on this question during the period 1966 - 1976, Hook and Rosenshine concluded that "if a teacher answers a questionnaire on a variety of specific activities, we cannot assume that these reports correspond to actual practice" (pp. 9-10).

Hence in the present research project teaching is studied neither through student achievement, nor through teacher responses to questionnaires, but instead through an examination of actual classroom teaching/learning discourse.

Methodological Considerations

The 'Grounding' of the Methodology

Two considerations convinced the investigator to adopt the methodology employed in the study.

First is a personal conviction that the aim of research in science education must be the improvement of science teaching and learning and, further, that the "keenest sense of improving practice concerns individual teachers in particular teaching situations" (Kilbourn, 1980, p. 162). Recognition of improving science classroom practice in this specific sense demands that research "focus on whatever events are most salient within a specific situation" (p. 162).

The second stems from personal conviction as well. The investigator is convinced that important understandings will come from studying the world of the classroom as it is constituted by observable discourse rather than some absolute world, or else the "world of the mind" (Heyman, 1983). Thus the study neither deals with some idealized preconceptions of utterances in chemistry teaching discourse, nor is it concerned with the 'private experiences' of the participants of a discourse. Instead, the concern is with the demonstration of the form(s) and function(s) of specific metacommunicative teaching utterances within 'natural' chemistry classroom teaching discourse.

In that sense the methodology of the present study is consistent with Easley's conceptualization of naturalistic studies. He points out that the term 'naturalistic'

> is intended to suggest the idea that all sciences go through a natural history phase in which one learns about the underlying structure of the phenomena and how they are organized. Then from that knowledge, one can proceed to a more quantitative or formal type of methodology . . . If we approach educational research in a naturalistic way, it could be simultaneously more scientific in the sense that it emulates the natural sciences and more helpful to classroom practitioners. (Easley, 1982, p. 193, emphasis added.)

The Importance of Contextual Gestalt

This study is a demonstration of the observability of the form(s) and function(s) of metacommunicative teaching utterances of interest within the total context of a classroom teaching/learning discourse. Thus, the study constitutes an empirical analysis of a classroom discourse in which meanings are not ascribed to isolated utterances. Instead a teaching utterance is assumed to have the attributed meaning if and only if it forms a part of a larger context. This is critical. Just as an artist's stroke with a painting becomes a flower here, a bird there, etc., but without the context of a painting it is merely a stroke of brush, so can an utterance be interpreted to have a particular meaning only within the context of a discourse. Lynch et al. appear to describe such a situation by a term - "autochthonous." They ascribe this term to Gurwitsch (1964) who "speaks of 'autochthonous' properties of 'gestalt-contexture', meaning the identifying properties of a figure with origins in the figure's ensemble presentation of its constituent features. These 'autochthonous' features are not reducible to any a priori definition of figural element, but arise within the composition of the figure's accomplished unity" (Lynch, Livingston, and Garfinkel, in press, emphasis added).

The rationale for approaching the pedagogic problem in this fashion can be summarized thus. Inasmuch as a classroom discourse is determined jointly by the teacher and his/her students within the context of a particular classroom, each teacher has to come to terms with the uniqueness of his/her instructional situation. No attempts, however careful, to follow a program of studies, or a curriculum guide, or a teacher's manual, textual material, etc., will relieve a teacher of the contingencies and the exigencies of a particular and unique situation. Similarly, the extraordinary insights and skills whether displayed or not within a given set of circumstances cannot be gainfully talked about in the idiom of student results. What counts as the world of classroom discourse is what actually obtains then and there, within the unique context of that particular classroom. According to this point of view the relevance of research must be "in terms of individual teachers in their unique settings" (Kilbourn, 1980, p. 163). The methodological approach attempted in this study seeks to discover and demonstrate the features of interest in and of a classroom discourse, as various utterances compose themselves within the embodied accomplishment of a lesson. Thus, the data come first. "Out of the data are teased descriptive patterns, hypotheses, perhaps theory . . ." (Smith, 1982, p. 628).

The Form of Generalization

This approach is favoured since the statistical models that have their origins in the so-called scientific paradigm are considered "more appropriate for studying simple, closed, static systems than for studying the complex, dynamic and open processes of classrooms" (Power, 1977, p. 20). Statistical studies, on the one hand, give little information about the context in which classroom events occur, yet the context provides these events with their meaning and existential qualities (p. 5). The 'methodological commitment' in the present study, on the other hand, is to the investigation of the phenomenon by employing methods of observation and analysis that preserve the integrity of the phenomenon.

But is generalizability sacrificed? To be sure, in an effort to constitute an adequate and intelligible explanation of what obtains, every attempt is made to maintain an objective perspective of the phenomenon. Nevertheless, this objection must be attended to: "there is no way of knowing whether the accounts are insightful and accurate models of reality or trivial, misleading impressions" (p. 22), and therefore idiosyncratic and non-generalizable. As Kilbourn has pointed out (1980, p. 168), such objections are inherent in "the basic tenets of a scientific paradigm - the assumption that replicable scientific generalizations about classrooms are necessary for improving practice." This is surely a question of whether an account of a phenomenon can be conceptually 'transported' from one context to the next. Easley treats that question as follows.

> Whether technically you have some sort of guarantee that there is universal application of a relation of rules that determine how and when to apply a particular concept is not terribly important, since in a given situation what counts is the ability to choose among all that you know what gives you the deepest understanding.
> (Easley, 1982, p. 200)

Similarly, in "praise of particularization," Stake suggests: to know "particulars" thoroughly is to recognize the same "in new and foreign context." Such "knowledge is a form of generalization too, . . . naturalistic generalization, arrived at by recognizing the similarities of objects and issues in and out of context and by sensing the natural covariation of happenings. To generalize in this way is to be both intuitive and empirical . . . . Naturalistic generalizations seldom take the form of predictions but lead regularly to expectations. They guide action" (Stake, 1978, p. 6). The kind of generalization that could be made on the basis of the present study may be limited by the specificity of a situation, but is nevertheless extremely important in terms of improving a given chemistry teacher's classroom practice.

Significance of the Study

Two kinds of considerations are taken into account to emphasize the significance of the study.

One is more general, and is to do with the understanding of a pedagogic phenomenon. Within this perspective the study must be viewed as the preliminary steps in a systematic description and identification of some salient features of chemistry teaching process with a view to uncovering the mechanism(s) that underlie(s) chemistry classroom teaching/learning phenomena. For, as Easley reminds science education researchers, teachers "need to understand what is happening in their classrooms so they can change their role in the social interaction to get better results" (Easley, 1982, p. 192).

The other consideration is more specific, and concerns the pedagogic problematic and the investigator's contention in that regard, as focussed in the present study. Thus, from the point of view of the 'difficult' reputation of chemistry and 'conceptual clarity' of teaching utterances, the study makes an important contribution by documenting and discerning what chemistry teachers try to do in order to increase the possibility for their students to learn what they (teachers) are trying to teach. In this connection, the study identifies some significant and promising pedagogic constructs for our understanding of the 'difficulty' experienced by chemistry students from the perspective of classroom teaching.

Limitations of the Study

Conclusions drawn from findings of such a narrow range of observations as involved in the present study have obvious limitations. For instance, inasmuch as the locus of the study is senior high school chemistry classrooms, the conclusions could pertain only to senior high school chemistry teaching. Again, inasmuch as the concern of this study is on verbal interactions the influence of non-verbal interactions on the findings needs to be taken into account in drawing conclusions. Similarly, since the present study is concerned with the cognitive aspects of chemistry teaching, the influence of interpersonal interactions must also be considered. Thus, although this study has generated intuitive insights concerning the process of classroom teaching, the conclusions can be supported for only the cognitive aspects of senior high school chemistry teaching as it occurs through verbal interaction.

It must be emphasized that the study does not attempt to provide a comprehensive answer to the question: "Why do students find learning chemistry difficult?" The study does not, for example, explore reasons (and remedies) for 'difficulty' inherent in the incommensurability of cognitive abilities of students and cognitive requirements of some of the chemical concepts involved in the course of studies. The study is also not concerned with various other psychological and sociological factors which may make the study of chemistry an arduous task for a student. By focussing on the process of chemistry teaching, the findings of the study point only to one particular way of understanding and minimizing the 'difficulty' experienced by students in chemistry classrooms.

CHAPTER TWO

Related Research

Introduction

This chapter is devoted to a brief review of related research. The purpose of the review is not to provide a comprehensive appraisal of chemical education research, or research on teaching, or for that matter of classroom interaction research. Several excellent reviews of such research already exist in the education research literature. Among the relevant and more recent of such appraisals are those by Kornhauser, 1979, on chemical education research; by Whitfield, 1979, on science teaching; by Bellack, 1981, on teaching; by Power, 1977, on science classroom interaction; and by Green, 1983, on teaching as a linguistic process. The purpose in presenting a review (this one might conceivably be called a meta-review) of related research is to emphasize the uniqueness of the present study. The related research is, therefore, analyzed to fit this purpose. This is attempted by making explicit in the analysis those features of related research that are considered appropriate and relevant to the investigator's purpose.

The rest of this chapter is organized into two sections. The first deals with literature search procedures, beginning with consideration of criteria for related research. This is followed by a description of this investigator's efforts at the appropriate literature search. The section culminates in the identification of three broad categories of related research. In the second section appropriate relevant research studies are examined to provide a background against which the uniqueness of the present study is made apparent.

Search Procedures

Criteria for 'Relatedness'

Embedded in the scope and nature of the present study are certain considerations that were taken into account in delimiting the related research. These considerations are:

1. the locus of interest as the senior high school chemistry classroom,
2. the focus of interest on teaching discourse rather than teacher or student or classroom environment related variables,

and 3. the concern with the teaching utterances within the context of a lesson discourse.

Thus, the related research must be about the teaching/learning verbal interactions during senior high school chemistry teaching discourse within natural classroom settings.

Literature Search

In order to determine the scope, nature, and findings of studies similar to the present study, a preliminary ERIC system search was conducted in November 1982 employing the following descriptors: "Secondary school science," "Science instruction," "Interaction process analysis," "Teacher pupil interaction," and "Discourse analysis." The ERIC search produced 78 references of interest, of which the abstracts of 31 studies were examined. However, only ten of these studies were concerned with senior high school science teaching--eight in biology, one in chemistry, and one in physics. Almost all studies cited employed some form of structured formal instruments made up of category systems of one sort or another. It seems that, "for the most part, classroom researchers have been content to describe classrooms in terms of the relative frequency with which events occur" (Power, 1977, p. 7).

In view of the preliminary ERIC search and due to the uniqueness of the present study, an extensive literature search was also undertaken manually, to ensure a more thorough coverage of published related research. This search spanned a period dating back to 1970, and in some cases even earlier, through the spring of 1983, and included the following journals:

1. Education in Chemistry
2. Journal of Chemical Education
3. Journal of Research in Science Teaching
4. Science Education
5. School Science Review
6. Studies in Science Education

7. Education Research Quarterly
8. Journal of Educational Research
9. Review of Educational Research
10. Review of Research in Education

11. Research in Education

12. Discourse Processes
13. Language in Society
14. Semiotica

Neither those journals nor some other miscellaneous journals reported studies of senior high school chemistry teaching discourse consistent with the approach and theoretical orientation of the present study.

Since no directly related research was found, and since the focus of interest is, after all, on teaching discourse, any study which dealt with science classroom teaching discourse was next regarded as related research. With this extended definition of related research in mind, a second ERIC system search was conducted in May 1983 using the descriptors "Science education" or "Science instruction" in conjunction with "Interaction process analysis" or "Classroom observation techniques"; with "Science education" or "Science instruction" as descriptors of major emphasis. This search yielded 58 references in the ERIC system some of which had also been cited in the first search. However, from the perspectives of the present study the results of this search were not much different from those of the first.

Categories of Related Research

The results of literature searches notwithstanding, the following three broad categories of related research are identified in order to organize the review of related research in the next section of this chapter. The categories emerge from the foregoing considerations of criteria. They are:

1. research on chemistry teaching,
2. research on (science) teaching process,

and 3. research on classroom teaching as a communicative process.

Analysis of Related Research

Research on Chemistry Teaching

General research in chemical education. In a major review of recent research and developmental studies based on some 250 reports from some 35 international journals, symposia, seminars, conferences, etc., during the period 1975 - 1977, Aleksandra Kornhauser (1979) identified "fundamental applied and developmental researches as the basic need of chemical education" (p. 22), and as the general trend of chemical education research for some time to come. She further suggested that

> the development of integrated teaching-learning theories, based on the nature of the chemical sciences, on psychological and sociological knowledge, and acknowledging the interactions between chemistry, curriculum, student, teacher and society, is now favoured. (p. 25)

However, this reorientation is comparatively recent. Most chemical education research continues to be based on partial approaches and/or on empiricism manifested in statistical research, survey research, content analyses, etc. A great many investigations concern the effects of different treatments as compared under experimental conditions, focussing on the usual categories (method of teaching, motivation, age, sex, I.Q., S.E.S., class size, etc.) as independent variables, and student achievement, attitude, comprehension, etc., as dependent variables. Findings of such research are of limited use, results are often non-significant and even contradictory, and findings are not helpful in drawing useful general conclusions regarding chemical education (Kornhauser, 1979, pp. 23-24).

To be sure, Kornhauser's review covered only a two-year period from 1975 - 1977, yet this general picture of research in chemical education continues to be true. For example, all nine of the studies in chemical education research reported in the Journal of Research in Science Teaching from 1978 to April 1983 are within the so-called statistical-scientific-experimental research paradigm (Hermann and Hinksman, 1978; Ben-Zvi et al., 1979; Gable and Sherwood, 1980; Ward and Herron, 1980; Hofstein et al., 1980; Cavin et al., 1981; Hartford and Good, 1982; McNaught, 1982; and Gable and Sherwood, 1983). So were the thirteen studies in chemical education research reported within the period 1971 - 1974 in the same journal. Similarly, the chemical education research reported in Science Education falls into the same category. Research reports in Education in Chemistry, Journal of Chemical Education, and School Science Review continue to be in the same vein (e.g., Deboer, 1980; Johnston and Percival, 1976; Walford, 1981; Cervallati et al., 1981; Bottomley and Ormerod, 1982; Lazonby et al., 1982; Freilich, 1982; Hillman et al., 1981; Bojezuk, 1982; and Kingdon and Critchley, 1982).

Research on chemistry teacher characteristics. Moving from general research in chemical education to those studies (Shrigley, 1976; Brown, 1977; Earl and Winkeljohn, 1977; and Simpson and Brown, 1977) that have investigated relationships between specific teacher characteristics and the teaching of science, Kornhauser appears more optimistic. However (1979, p. 24), "In the main, these studies have focussed on elementary teachers and their teaching of integrated science," "Chemistry teachers have not been the subject of these researches," and "Studies at the secondary level are relatively rare (e.g., Lazarowitz, 1976, and Lazarowitz and Lee, 1976)."

Even in this area of research in chemical education no clear cut picture is emerging. Whereas many studies are critical of teachers as perpetuating a traditional conservative stance, some (e.g., Piper and Butts, 1976) regard the situation to be too complex to draw simple and useful conclusions. Berliner (1976) doubts whether we can indeed measure 'teacher effectiveness' and Chisholm (1977) states that "excellence in teaching has proved to be indefinable and therefore immeasurable."

In summary, the contention by many writers that there is a paucity of appropriate relevant research (and therefore that it is difficult to draw useful general conclusions) in this field of chemical education research further confirms the investigator's up-to-date literature search.

Research on classroom chemistry teaching. Turning now to the chemistry classroom note Kornhauser's observation (quoted now for a different purpose) that

> in spite of the widely accepted statement that the educational process has to be a process of communication involving all its participants, there have so far been only a few studies undertaken on student - student interaction. A few critical analyses have been carried [sic] on team work in education; team work of students, of students and teachers, and team teaching. (Kornhauser, 1979, p. 25)

But what goes on inside a chemistry classroom, and how chemistry teachers teach chemistry effectively, are matters that are by and large left unexplored. Such questions can be answered only by observing chemistry teachers in their classrooms as they teach chemistry. Such research is still in its infancy (Johnson, 1977). The present investigator in his literature search came across scant evidence of research studies in which chemistry teaching discourse as it occurs was the focus of investigation. For example, Munby (1969) analyzed chemistry lessons, but his purpose was to develop an analytic scheme for analyzing science teaching on the basis of three philosophical models of teaching--the Impression model, the Insight model, and the Rule model--as proposed by Scheffler (1965). Thus his focus was on the philosophical models rather than on the teaching of chemistry. In other words, he could have just as well selected some other science lessons, as indeed he did in a later study (Munby, 1973), for he made no comments specific to chemistry teaching.

Ramsey (1969) also analyzed high school chemistry teaching by teachers of the CHEM STUDY program. But, his focus was on the development of a category system to describe content development in chemistry classes, and on the use of the system to characterize the approaches adopted by teachers as they develop chemistry content in their classes.

Norton (1970) observed classroom verbal interaction in a college chemistry class employing Flanders' system of verbal interaction analysis, with a focus on the knowledge and comprehension of students in college chemistry as related to so-called 'direct' and 'indirect' teaching. His was thus a correlational study and not a contextual examination of chemistry teaching. Similarly, Wolfson (1970) sought to determine a relationship of high I/D (Indirect to Direct) and low i/d ratio teaching with increasing student achievement and retention of learning. Here again, although Wolfson observed classroom teaching and employed Flanders' scheme to describe and characterize chemistry teaching, his focus was on student achievement and retention of learning by students. This was also a correlational study rather than a contextual study of chemistry teaching discourse.

In a pilot study Johnson (1977) examined chemistry teaching of some Nuffield chemistry teachers. But like the above mentioned studies the focus of his study was not the teaching of chemistry per se. Johnson's focus was on the relationships between teachers' intention, action and the teaching topic.

From the methodological point of view Munby's approach (1969, 1973) to teaching discourse and Johnson's pilot-study (1977) come closest to the present study. For example, Munby draws his conclusions on the basis of the examination of entire lesson transcripts. Similarly, Johnson combines the examination of actual teaching interactions with the category system -- "Science Teaching Observation Schedule" -- in order to draw inferences for his study. But unlike these and other research programs in which the interest is on the philosophy of science, or philosophy of science teaching, or teacher characteristics, or student achievement, etc., the present study seeks to examine teaching discourse and document monitoring by the teachers themselves for consensus on what is being taught and learnt. Thus, the focus in the present study is on the phenomenon of chemistry teaching itself.

To sum up, most research in chemical education has been and still is applied and developmental. The relatively limited success of the research approaches usually employed has prompted a search for new methodology for research in chemical education "away from artificial 'arranged' situations to education in its natural environment" (Kornhauser, 1979, p. 26). Naturalistic observation coupled with contextual understanding of the phenomena is one such approach that the present investigator favours--that is, to observe the classroom teaching-learning discourse in an effort to understand the phenomena as teachers themselves seek to determine whether what is being learnt is what they are attempting to teach.

Research on (Science) Teaching Process

Quantitative research. Whereas there appears to be a dearth of research studies with a focus on high school chemistry teaching discourse, there is an abundance of research on teaching in general. In the main, this research is carried on within the research outlook commonly referred to as "quantitative research." The methods of quantitative research form what has come to be known as the "descriptive-correlational-experimental loop" (Rosenshine and Furst, 1973). But most quantitative studies of teaching are correlational-experimental studies within the "teacher effectiveness" or "process-product research" paradigm, with focus on some teacher behaviour as the independent variable, and on student achievement as the dependent variable. And as Bellack points out,

> in focussing exclusively on the two types of variables, the process-product model ignores not only the reciprocal influences of classroom participants on each other, but also the influences of contextual frame factors on teacher-pupil interactions. Further, in assuming a direct causal link between teacher behaviour and pupil learning, the model also ignores the impact of both teacher-pupil interactional processes and environmental factors on effects of classroom events. (Bellack, 1981, pp. 63-64)

Descriptive studies. There seems to be a serious dissatisfaction with the findings of quantitative research among educational researchers. This is evidenced by the emergence in the early 1970s of a new outlook --"the interpretational paradigm"--for research on teaching (Bellack, 1981).

An early lead in the development of this outlook was provided by a call for "descriptive" studies by B. O. Smith, who argued that the failure of research studies in teacher behaviour

> to yield a body of consistent knowledge about instruction indicates that perhaps they are premature, that more direct and primitive analyses of teaching behaviour are needed as a preface to experimental and correlational studies. (Smith and Meux, 1958, p. 2)

In defence of descriptive studies, Smith contended that,

> if very little is known about a phenomenon, the way to begin an investigation of it is to observe and analyze the phenomenon itself. It must be observed, analyzed, and classified into various elements. Until factors which are involved in the phenomenon are understood and described there is little likelihood that significant correlational, predictive or causal studies can be made. (p. 8)

The call was taken up by numerous researchers, among them Flanders, who set themselves the task of developing taxonomies for the description and analysis of classroom teaching. These efforts resulted in an explosion of category schemes in the same vein as the Flanders Interaction Analysis

System (Simon and Boyer, 1970).

But on the whole, descriptive studies based on category systems appear to be preoccupied with the "process-product research" paradigm. For example, Evans (1970), in a review of such studies using Flanders' system in science classes, suggested that there is some evidence that the technique is useful for identifying some aspects of teacher effectiveness. But no clear relationship between teaching styles and teacher effectiveness has been shown in the studies he reviewed.

Similarly, in a more comprehensive survey of research in science education, Balzer et al. (1973) found that studies had continued to focus on comparisons of teaching methodologies and their effectiveness. Researchers had continued their investigation into the relationship between, on one hand, teacher traits, characteristics or personalities and, on the other, effectiveness. Although the reviewers did not find clearcut relationships between teacher classroom behaviour and the selected criteria of effectiveness, they did not negate the probability of the existence of such a relationship. "The problem was, and is, to identify these relationships and then to explain why they occur" (p. 148).

The main purpose of studies in this paradigm seems to be the identification of discrete, quantifiable teacher behaviours as teaching process variables to be employed in "process-product" research (Bellack, 1981, p. 62). Questions as to 'how' and 'for what purpose' various classroom teaching practices come to be established are by and large left unanswered by these studies. Yet, these are the central questions in our attempts at understanding the phenomenon of teaching. To answer these questions some means must be devised that will highlight the essential and the salient features of classroom teaching within its actualized contextual reality.

But the predominant methodology of research in the processes of teaching (science) continues to be in terms of discrete categorization of the phenomena. A recent example of such a category system is the Science Teaching Observation Schedule -- STOS -- developed in the U.K. during the early 1970s (Eggleston et al., 1976). STOS has been employed by Eggleston and his associates in 1979 and 1980 in the U.K., and by Hacker in 1979 in Canada, for the study of science teaching (Eggleston, 1980). It is a system in which behaviours are recorded as they occur in mutually exclusive categories using three-minute time-sampling units. It is a research tool specifically designed for a process-product type of study in which teaching styles are defined in terms of intellectual transactions and can be correlated with specified outcome measures (Eggleston et al., 1976, p. 39). It is interesting to note that STOS is focussed on "intellectual transactions," with the underlying assumption that during teaching the "free flow of intellectual exchanges" is not inhibited either by "ineffective management" or by adverse "affective climate" (Eggleston, 1980). But surely such 'limiting conditions' can be met only infrequently in actual instances of science teaching. If not met then how would these 'limiting conditions' affect the outcome of the studies employing STOS? And, how is the effect of these limiting conditions on the outcome of these studies to be accounted for? It would appear that these questions have largely been left unattended by the developers of STOS.

Contrasting methods in descriptive studies. To be sure, within the predominant research methodology of science teaching there are variations in approach. One approach, as mentioned earlier, is concerned with organizing the teaching/learning discourse into predetermined categories chosen to provide as comprehensive a taxonomy of interest as possible. For example, in one part of an eclectic study of high school biology classes in Israel, observers recorded every minute: (a) what is going on, (b) who talks, (c) place and position of teacher, and (d) organization (Tamir, 1981, p. 88).

Another approach is to determine, a priori, a specific dimension along which a process of teaching would be placed if and as it varies. For example, Herron (1971) used the dimension 'level of openness' in relation to the process of 'discovery' or 'inquiry' teaching, in his study of BSCS and PSSC teaching. The 'level of discovery' varies in Herron's study from zero to three. At the zero level--the least 'open' level--the problem, the method(s) and the answer(s) are all provided. At level one only the answers are left open, and at level two only the problem is given. But at level three--the most 'open' level--all these three elements of the process of inquiry are left to the inquirer to discover (p. 200). Similarly, Tamir places each sub-category of the 'nature of teaching' on a continuum with contrasting extremes on the opposite poles of a five point scale as follows:

Abstract	1	2	3	4	5	Concrete
Theoretical	1	2	3	4	5	Practical
Nondirected	1	2	3	4	5	Directed

(1981, p. 89)

Other suggested dimensions in this approach include the continuums:

teacher-initiated - pupil initiated, didactic - heuristic, etc. (Eggleston, 1980).

Yet another variation in approach is to first observe and record the entire science teaching process and then, by employing some meta-theoretic organizing principles, categorize the process into discrete categories. The category system so devised is then used to observe other instances of the process (cf. Eggleston 1980). This approach was employed by Aschner (1965); by Smith and Meux (1967); by Parakh (1967-68 and 1969); by Gallagher (1970); by Tisher (1970); by Eggleston et al. (1976) and by Hacker (1979). More recently, borrowing for his study from the category systems of earlier researchers, Tamir obtained eclectic analytic schemes to categorize teacher questions, modes of teaching and instructional techniques (1981, pp. 90-92).

A new focus for research. All of these approaches nevertheless result in category systems and the teaching is described in terms of frequency counts. Thus the aim of such research is to describe teaching in a quantitative manner with a view to conduct correlational studies in which descriptive teaching variables are related to some specified measure of student growth. The ultimate objective is to undertake experimental studies in which more significant variables, as identified through correlational studies, are tested under more controlled conditions (Rosenshine and Furst, 1973). And in the case of science teaching Eggleston (1980, p. 264) rather optimistically claims that research has entered the correlational study stage.

The core objective of such studies then is to discover law-like statements concerning effectiveness of teaching through the observation of teacher behaviours and measurements of student achievement. To do this quantitatively, the teaching process of necessity is broken up into many component parts or variables. But most experimental designs permit a very few of these variables to be studied in any single study. As far as this investigator could ascertain, no valid general laws regarding teacher effectiveness have emerged from these studies. More sophisticated techniques, meta-analysis for example, may permit more global conclusions which may be otherwise useful but are seldom effective in improving an individual teacher's teaching situation.

Faced with such a situation, some researchers including this investigator are changing their basic question on teaching. Instead of asking "What works?" or "What works for whom?" or "What goes with what?," etc., we should be asking "What is happening and to what purpose?" It is by asking such questions that we can gain a more satisfying understanding and a more useful control of teaching process (cf. Clark, 1978-79, p. 54). To understand teaching in this fashion is to understand teachers' goals, judgements and decisions as manifested in their teaching behaviours within the context of their classrooms.

More importantly, Clark noted (and it is consistent with the focus of the present study) that we should seek to understand the "vital signs of the classroom that teachers monitor and use to organize, guide and maintain the learning environment" (p. 55). In a recent review of research on teachers' pedagogical thoughts, judgements, decisions and behaviours, Shavelson and Stern (1981) conclude that during interactive teaching the main concern of teachers appears to be the smooth flow of their preplanned activities. Teachers regularly monitor their classrooms in order to evaluate the routine, i.e., whether the activity is going as planned. It is interesting to note that out of 31 studies from a period 1969-80 in the Shavelson and Stern review none was about senior high school science teaching. And every study cited in this review focussed on teachers' routine reliance on pre-established student characteristics as salient cues to monitor classroom activities.

New questions for the new focus. But what are some of the vital features of teaching/learning processes and how do teachers monitor these to organize, guide and sustain the teaching/learning environment? For example, how do teachers ensure that their teaching discourse is neither too difficult nor too easy so that their students do not give up on learning what they (teachers) are trying to teach? What teaching strategies do teachers employ for such a metapurpose? How can such teaching concerns be illustrated through various teacher utterances in the classroom discourse? How are we, as researchers, to understand the 'monitoring' behaviour of teachers as just such a behaviour? These are the types of questions that are addressed in the present study.

As far as the present investigator could ascertain only Gallagher and Aschner's (1963) concept of "monitoring feedback" comes close to some of the conceptualizations in the present study. According to them, "monitoring feedback" is a teacher behaviour through which a "teacher attempts to ascertain whether or not the student or the class as a whole understands the point that he is trying to make" (p. 190). They place this behaviour in a category called "routine," which consists of miscellaneous classroom activities. Also included in this category is teacher clarifying behaviour, through which a teacher attempts to make sure that all students in the class grasped the point that a particular student was trying to make (p. 190). However, these researchers do little else other than recognizing that such teacher behaviours do occur. One wonders what other purpose or role beyond the immediate and the obvious inference such teacher behaviours serve in the overall process of accomplishing lessons in classrooms.

The main thrust of the Gallagher and Aschner study is the development of a category system concerning the operation of intellect and consisting of cognitive memory, convergent thinking, divergent thinking, evaluative thinking, and routine categories (p. 186). The goal of their research program was "to arrive at a description of the intellectual processes that occur in the classroom" (p. 193), rather than an understanding of the teaching process per se, as it actualizes within the contextual reality of a classroom (or from the point of view of, say, teachers' attempts to modify the level of difficulty of their discourse).

More recently, researchers are exploring new ways to study a variety of educational concerns including the nature of effective instruction (cf. Green, 1983, p. 151). In one such approach, that this investigator favours, teaching is regarded as a process of linguistic communication. This approach is considered in the next section of this chapter.

Research on Science Classroom Teaching as a Communicative Process*

Among the several new approaches for the study of teaching/learning to emerge in the last decade is "teaching as a linguistic process" (Green, 1983, p. 151). In this still evolving field of inquiry, researchers are concerned with, among other questions, how language through the interactions between teacher and students functions in support of the acquisition of various knowledge forms (p. 168). In what follows, some of the conceptualizations that define and guide research in "teaching as a linguistic process" are discussed albeit briefly.

Patterns of language in classroom discourse. Classroom teaching/learning as face-to-face interaction is a rule-governed phenomenon. Thus the significant questions are: What are recurrent patterns of language use?, How are messages received and/or responded to?, What are characteristic cases of interaction within a single, as well as across various, educational settings?, etc. (p. 174). And, the objective of the researchers is to capture the nature of the process from the perspectives of the participants. The methodology is to examine the phenomenon in its actualized reality.

Ever-evolving context. The concept of context is unique in this field of inquiry. It is not the situational context, but rather the context as constructed by the participants through their participation in face-to-face rule-governed interaction. As such, context is ever-evolving. Therefore, the notion of "contextualization cue" becomes important in understanding the ongoing face-to-face interaction. And in classroom settings the constancy as well as the variability of contextualization cues becomes a significant question for the understanding of teaching as a linguistic process. Some of these activities do become ritualized. It has been argued that classroom teaching/learning process lies somewhere between ritualistic and spontaneous on a continuum (p. 175).

---

*This discussion is based solely on Green's (1983) comprehensive review on teaching as a linguistic process. All page references are to this review.

Meaning as context-specific. Closely related to the concept of "context as constructed" is the conceptualization of meaning as "context-bound." Not all instances of a given behaviour are considered functionally equivalent. How a given behaviour is to be understood depends on how it is used, what came before it, and what came after. In this sense meaning is considered context-specific within the perspectives of an ever-evolving context (p. 177). A similar point is made by another appraiser of educational research methodology in asking the question: "Is there any other kind of meaning?" Accordingly, the

> interpretation of any particular utterance... depend[s] upon its context. The meaning of any particular utterance both for participants and the investigator reflect[s] our respective understanding that it was located in and part of... talk. The phenomenon... was itself being constructed in and through the talk. (Mishler, 1979, p. 16)

Meaning as an inferencing process. Meaning, therefore, becomes simply a process of extracting information from face-to-face interaction in order to make sense. Thus, it is an "inferencing process" (Green, 1983, p. 179). Research in the inferencing process through microanalytic techniques permits exploration of effective practices in classroom teaching and learning (p. 180). Associated with meaning as inferencing process is the notion of "frame of reference" with its nuances of "frame commonality"* and "frame clash." Pedagogically the notion of frame of reference is of extreme importance. Microanalysis of the language of classroom interaction provides valuable information in this regard and consequently for consensual* and/or inconsensual* teaching discourse (pp. 180-82). The concept of classroom teaching/learning as rule-governed face-to-face interaction, and the attendant constructs of ever-evolving context, context specificity of meaning, and meaning as an inferencing process lead to the conceptualizations of classroom as a "communicative environment" and teaching as a "communicative process."

Rights and obligations of teacher and students. The conception of classroom as a communicative environment brings to the fore the rights and obligations of teacher and students as communicants within the perspective of the requirements of a given classroom setting. The questions of significance in this connection concern the constancy and variability of "rights," "obligations" and "requirements" of various pedagogic situations. The answers to such questions have important implications for the understanding of the teaching/learning phenomenon in its natural classroom settings (pp. 182-183).

Asymmetric role of teacher as monitor. The conception of teaching as a communicative process focusses on the teacher's role as instructor.

---

*These terms are not mentioned in Green's review (1983). These are some of the conceptualizations employed in the present study.

As an instructor the teacher plays an asymmetric role as an "orchestrator" and a "monitor" of the classroom communicative system. This is of course in addition to his role as presenter of academic content, controller of discipline, and manager of the routines. However, an important role of the teacher is in the ongoing monitoring and evaluation of student performance during classroom interaction. Despite the difficulties associated with such a task, the potential consequences of such evaluation for the students cannot be over-emphasized (pp. 184-185). Similarly, an ongoing monitoring of the entire teaching discourse for consensual* teaching/learning with its potential consequences for both the teacher and the students is an equally important pedagogical concern.

Centrality of naturalistic setting. It has been suggested by researchers in the "teaching-as-a-linguistic-process" paradigm that, by observing the actions of teachers and students in a classroom communicative system, both the participants and the researcher can infer the purposes that participants intuit to various processes that actualize in such a system. This suggestion points to the centrality in the methodology of this paradigm of examining face-to-face interactions in natural classroom settings.

In concluding this discussion, it is interesting to note that, of the several research programs Green reviewed within this paradigm, not a single project was focussed on senior high school science classrooms as communicative systems. Neither was any section assigned to a collection of representative research findings focussing on the ongoing guidance and sustenance of a consensual teaching/learning interaction

---

*See footnote p. 37.

(cf. pp. 233-243). This is despite the recognition (a) that teachers and students view classroom interactional events at times from similar perspectives and at other times from different perspectives (p. 224), and (b) that "classrooms were defined as environments in which teachers and students develop shared meanings for activities" (p. 226). To be sure, it is suggested that "additional work needs to be undertaken to explore the ways in which teachers can use strategies for obtaining students' perspectives as instructional resources" (p. 225). One would suggest that a prior work to be done is to explore the very strategies that teachers employ to gain students' perspectives of the instructional process. Nevertheless, the notions of "frame of reference" with its nuance of "frame clash," in addition to the concept of "classroom as a communicative environment," provide support to the theoretic orientation employed in the present study. Also, the centrality of observing teaching/learning interactions in natural classroom settings, with its attendant concepts of "context as constructed" and "meaning as an inferencing process," give additional support to the methodology employed in the present study.

Summary

The foregoing review of prior research emphasizes the uniqueness of the present study by comparing and contrasting the salient features of the study with some related research. The latter is delimited by considerations of the focus of study and the investigator's contention in that regard. Thus, the related research, for the purpose of this review, is organized into research on (a) chemistry teaching, (b) teaching process, and (c) classroom teaching as a communicative process.

Although considerable research effort has been expended on applied and developmental research in chemical education, there appears to be a dearth of studies with a focus on high school chemistry teaching discourse. Despite the widespread recognition that students find chemistry a difficult subject to learn, this investigator, in his literature search, did not come across studies exploring chemistry classroom teaching/learning discourse from the perspective of this significant pedagogic problematic.

On the other hand, there is an abundance of studies of teaching in general, carried on, in the main, within the "quantitative research" paradigm. Despite a serious dissatisfaction with the findings of quantitative research among educational researchers, and the emergence of a new outlook in the 70s -- "the interpretational paradigm" -- for research on teaching, the latter continues to be described in terms of frequency counts within diverse "category systems." Researchers within the predominant paradigm have argued that more sophisticated techniques of quantitative research may permit more global conclusions. Yet, others have recognized that such conclusions are seldom effective in improving an individual teacher's teaching situation. This realization is causing a shift in methodology employed by some researchers, towards a naturalistic observation and contextual understanding of educational phenomena.

A promising approach in the new methodology treats teaching as a "linguistic process." In a somewhat similar vein this investigator regards teaching as a "communicative process" within a classroom as a "communicative environment."

It becomes clear from the review of related research as presented in this chapter that the need and importance of some of the conceptualizations as employed in the present study have been variously recognized. However, no systematic and "naturalistic" study has been undertaken into teachers' attempts or strategies to ensure the consensuality of their teaching/learning discourse, especially in senior high school science or chemistry teaching with the metapurpose of understanding the difficult reputation of chemistry. The present study is an attempt in this direction.

CHAPTER THREE

Theoretical Perspectives

This chapter elaborates a point of view about teaching and defends its use as an orientation for analyzing chemistry classroom discourse. While the methodological orientation of the study was elaborated in the preceding chapter, inevitably some comments about methodology appear in the present chapter as well. The several relevant premises on which the investigator draws have an eclectic origin in the writings of several recognized scholars, whose general influence on this study is acknowledged as such. References are made only to those works that have most directly shaped the theoretic orientations and the methodology of the present investigation.

Various premises in this chapter are centered around the main conceptions of classroom teaching as a "communicative process" within classroom teaching/learning as a predominantly verbal "communicative system." Not only the methodology of the present investigation but also the analytic orientations developed for this study are grounded in these conceptions. To be sure, these conceptions and various premises centered around them are multifaceted and can be discussed along a multitude of dimensions. Their explication in this chapter, of necessity, is restricted to the immediate focus and the task of the present study as outlined in Chapter One and implied in Chapter Two.

This chapter is, then, organized into three sections. The first section is devoted to an explication of the concept of classroom teaching as a metapurposive communicative process in an asymmetric, triadic communicative system. The metapurpose is made explicit, and the notions of triadic relationship and asymmetry in classroom teaching/learning discourse are explained. A term 'pedagogic tactics' in teachers' communicative repertoire is introduced and an 'upshot' of these tactics for learners is defined. And, the distinction between pedagogic tactics of monitoring for control and monitoring for modification of teaching discourse within the perspectives of the metapurpose and the upshot for learners is discussed. In concluding this section the importance of metacommunication and especially the primary metapurposive metacommunicative utterances is emphasized.

In the second section the pedagogic concerns that underlie the metacommunicative utterances of interest for the study are explicated through John Ziman's communal knowledge model of science. The pedagogic concerns involved are to do with the consensuality of teaching/learning discourse, consensibility of teaching utterances, commonality of frame of reference in classroom discourse, and the commensurability of the discourse topic and its subject matter.

The chapter is concluded in the third section in which the emergent analytic and methodological orientations for the study are summarized.

Classroom Teaching as a Communicative Process within Classroom Teaching/Learning as a Communicative System

Classroom Teaching as a Communicative Process

It is a truism to say that in order to teach one must communicate.

The notion of communication in any formal teaching/learning process is supported by many an attempt at defining the concept of teaching. For example, when Jackson (1971, pp. 7-8) makes a plea for the need to understand "preactive teaching" in order to understand "interactive teaching" situations, he is surely envisioning a direct communication between the participants in the latter, and a sort of pre-communicative stage in the former, situation.

Thus, if students are to learn in the classroom of a teacher the teacher must communicate with them. And so, "the teacher communicates something to his partner; his peculiarity is that what he communicates is appropriate to a partner who is a pupil--it is something which may be received only by being learned" (Oakeshott, 1971, pp. 13-14).

Whereas Oakeshott is quite explicit, it is not difficult to discern the underlying and implied notion of communication in the teaching/learning process in the assertion that "Teaching is, above all, a linguistic activity," and that "language is inextricably involved in the process both of learning and of teaching," i.e., "it is at the very heart of teaching" (Smith, 1971, p. 24). For, to use a language is at least to attempt to communicate.

Similarly, "To teach, in the standard sense, is at some point at least to submit oneself to the understanding and independent judgement of the pupil, to his demand for reasons, to his sense of 'what constitutes an adequate explanation'." And, "teaching, in this way, requires us to reveal reasons to the students and, by so doing, to submit them to his evaluation and criticism" (Scheffler, 1971, p. 37). If teaching involves all that, then one must presuppose communication between teacher and pupil.

On the other hand, one must presume a lack of communication between teacher and learner, if the teacher leaves the learner unaffected (Komisar, 1971, p. 59). The notion of uptake of teaching by the learner points to the bipolarity of outcomes of pedagogic communication; that is, either the student learns what is being taught or does not get it at all. "But there is at least one intervening stage (and probably more) between learning and nescience" (Komisar, 1968, p. 77). Even Komisar's intervening stage--"some form of awareness" on the part of the student --as "the intended upshot in the teaching act," then, presupposes some form of communication between the teacher and the students (p. 79).

These and several other attempts by the above mentioned as well as many other scholars in defining the concept and clarifying the nature of teaching, either explicitly or implicitly involve the notion of communication between a teacher and his/her students.

Teaching/Learning: A Triadic Communicative System

Such attempts, while clearly underscoring the role of communication in the teaching/learning process, bring out only dyadic relationships between various elements of the system--such as are illustrated by the statements: "I teach children," or "I teach chemistry," and in the misconstrued dichotomy between "teaching children" and "teaching chemistry," etc. These dyadic relationships, in themselves, are not enough for an adequate clarification of the conceptions of classroom teaching as a communicative process and classroom teaching/learning as a communicative system. Hence, these conceptions are not of much use in guiding analysis of teaching in empirical research.

For a communication system to exist, we need both the communicants and something to communicate about--a subject matter. Recognition of the need of this third element--the subject matter--in a classroom communication system requires that teaching be regarded as a triadic relationship involving "at least one teacher, at least one pupil and a subject matter to be taught and learned." Such a triadic relationship must be built into our definition of teaching as a communicative process, "because when one of three elements is missing, the other two become disconnected and teaching cannot take place" (Hyman, 1971, p. 63).

Thus, it is not enough that in teaching there should be an intention to bring about learning and that the learner should recognize such an intention (Komisar, 1968, pp. 79-80). In addition, there should be an "intelligible indication to the learner of what is to be learned" (McNeill, 1983, personal communication). Such a triadic relationship in classroom teaching/learning as a communicative system is also implied by Hirst (1971). Accordingly, in formal teaching situations, both the teacher (T) and the learner (L) communicate with each other about some intellectual and/or physical knowledge and/or skill (X), such that the intention of (T) is teaching (X) to (L) and the intention of (L) is to learn (X) from (T).

The Metapurpose in Teaching as a Communicative Process

The intentions of both (T) and (L), though necessary, are not in themselves sufficient for an operational communication between (T) and (L). There is necessarily a gap between the intellectual knowledge and/or physical skill of the learner and what is to be learnt (Hirst, 1971, p. 14). Therefore, for a teaching activity to be classed as an operationally communicative activity, (T) must not only necessarily communicate about (X) with (L), (T) must do so with a cognizance of the present state of knowledge, skill, etc., of (L) so that it is possible for (L) to learn (X) (Hirst, 1971). For, if teaching is carried on through communication and it is impossible for (L) to learn (X), it would indeed be odd to classify a (T)'s own intention fulfilling activities as teaching (Hirst, 1971, p. 14), much less (T)'s attempts as communicative acts.

One is not concerned here with the dichotomy between the 'intentional' sense and the 'success' sense of teaching, and hence of communication. Instead, one is concerned with the operational or existential sense of teaching as a communicative process. To borrow an analogy from communications technology, there must be a "frequency-synchronization" between the transmitter and the receiver in order for the receiver to receive the transmission; and the finer is this synchronization the clearer is the communication. So it is in teaching/learning as a communicative system; it is a matter of (T) and (L) being on the same "wave length," so to speak.

To recapitulate then, classroom teaching as a communicative process within classroom teaching/learning as a communicative system implies that teaching activities not only must apparently express to (L) that (X) is to be learned, but also must do so in a way that it may become possible for (L) to learn (X).

Viewed from such a vantage point, classroom teaching/learning may be regarded as a special kind of communicative system with its own distinctively unique characteristics. Two of these characteristics are of special interest for the present study. One is to do with a special coupling of teaching and learning processes, and the other concerns the asymmetry of rights and responsibilities of teachers and students within a classroom pedagogic communicative system.

Classroom Teaching/Learning as Unique "Unequal-Power Discourse"

Asymmetry. To say that classroom teaching/learning is a special kind of communicative system is to place it in the same category as the doctor/patient interview, or the discourse of court trials, etc., that sociolinguists call unequal-power discourse (Hatch and Long, 1980, pp. 16-27). In such discourse the authority to control and manage the discourse, and the responsibility to sustain and guide it towards a desired end, resides in the participants with greater power. In a classroom teaching/learning discourse such rights and responsibilities rest asymmetrically with the teacher as has been revealed by numerous studies of classroom discourse (p. 17). For example:

> The pedagogical roles of the classroom are clearly delineated for teachers and pupils. Teachers are responsible for structuring the lesson, soliciting responses from pupils, reacting to pupils' responses and, to some extent, summarizing aspects of the discourse. The pupil's primary task is to respond to the teacher's solicitations. Occasionally pupils react to preceding statements, but the reactions are rarely evaluative. Pupils do not overtly rate teachers' statements, and they rate other pupils' responses only when the teacher asks them to do so. (Bellack et al., 1969, pp. 84-85)

Whereas the classroom teaching/learning system is a typical illustration of unequal-power discourse such that the subject matter of discourse, (X), is possessed by (T) and is supposedly to be acquired by (L), the objectives of the two participants are not mutually exclusive.

Special coupling. To say that classroom teaching/learning is a distinctly unique communicative system is to link the processes of formal teaching and learning in a constitutive relationship within the system. Just as a teacher and students constitute its necessary participants, both teaching and learning constitute the essential processes in a classroom communicative system. Either of these processes, by itself, cannot establish such a pedagogic communicative system. It must be emphasized that the two processes--teaching and learning--are quite distinct from one another. No relationship between these processes either in the intentional sense or the success sense of teaching is implied by this coupling linkage. The operational relationship implied here is purely constitutive in nature. Nevertheless, these two distinct constituent processes make classroom teaching/learning unique as a communicative system.

For example, no process corresponding to learning is of concern in doctor/patient interviews. The main constitutive process is the diagnosis of the illness by the doctor. Similarly, in a police/suspect interrogation the process of concern is the police-centered process of determining whether "charges" ought to be laid against the suspect. No suspect-centered process corresponding to learning is even an issue. Again, in a lawyer/witness communication in a courtroom the main process of concern is the lawyer-centered process of making a plausible case.

Whether such processes ought to be conducted without a cognizance of the processes centered around the participant with less power is not an issue here. But, by contrast these and other similar examples do amply demonstrate the uniqueness of the classroom teaching/learning communicative system--where the concern is not only with the teacher-centered teaching process but also with the learner-centered learning process.

Such a perspective of classroom teaching/learning as a uniquely distinct unequal-power communicative system places the onus for the attributes of the classroom teaching/learning discourse on the participant with greater power--the teacher.

Pedagogic Tactics, Metapurpose and the Upshot

What are the pedagogic moves that teachers make through their metacommunicative teaching utterances that not only sustain the teaching/learning discourse but also guide the latter towards the desirable goal, i.e., the possibility that a learner can learn? The search for these 'pedagogic tactics' is of great importance both for understanding formal teaching as a communicative process, and for discerning the 'upshot' of these tactics for the learner vis-a-vis the subject matter of the teaching discourse. Whether a student or a group of students finds a teaching discourse about a subject matter difficult to grasp or easy to understand will depend on the extent to which the teaching discourse has been conducted in a manner such that it is possible for the students to grasp and to understand the subject matter of the discourse.

To say this is to state a truism. But, how does a teacher determine that his/her teaching discourse is being conducted in such a(n) (un)desirable manner? And how can we as researchers demonstrate a teacher's attempts to determine just such qualities in his/her ongoing teaching discourse? In other words, how can we demonstrate the monitoring-for-feedback by the teacher of the status of his/her teaching discourse with the aforementioned 'upshot' for the learner in mind?

Monitoring for Control versus Monitoring for Modification

The embedded notion of the aforementioned 'upshot' for the learner in the monitoring and feedback activities of the teacher necessitates a fresh look into these activities as uniquely salient features of classroom teaching. The embeddedness of such a notion also compels us to make a distinction between monitor-to-control on the one hand, and monitor-to-modify on the other. Whereas the former implies a static relationship between various elements of a system, the latter reflects a dynamic relationship. Whereas the former is concerned with the maintenance of a status quo of a system by an "off-on," "right-wrong," "do-don't," etc., type of reaction, the latter is concerned with modification of the performance of an ever-evolving system as a whole towards a desired objective.

So too in a classroom teaching/learning communicative system, the teacher needs to know about the concordance between his/her teaching on the one hand, and his/her students' learning on the other. And, the teacher needs to know this during the ongoing process of teaching/learning in order to effectively and efficiently increase the degree of concordance between teaching and learning. It is for this reason that "end-of-unit" testing and "year-end" grading are ineffective and inefficient feedback designs for formal teaching/learning systems. To be efficient and effective in modifying their teaching discourse, teachers need to know while teaching that their utterances are being received clearly, and that the messages contained therein are being understood unambiguously, such that there is a maximum possible concordance between their teaching and their students' learning.

Importance of Metacommunication in Teaching Discourse

It is through increased concordance and consequently decreased discordance that teachers can attempt to minimize the difficulty felt by their students--not only towards their teaching discourse but also towards its subject matter. Since classroom teaching/learning is a distinctly unique unequal-power discourse, teachers incessantly have to use language with primarily a metacommunicative function, i.e., communication *about* their communication (cf. Jakobson, 1960, p. 352). Some of these metacommunicative functions serve the purpose of "attracting or showing attention," "controlling the amount of speech," "checking or confirming understanding," "summarizing," "defining," "editing," "correcting," "specifying topic" (Stubbs, 1976, pp. 159-61), etc. Such examples of metacommunicative functions, however, serve the purpose of "monitoring the working of communication channels, clarifying and reformulating the language used" (p. 162). And through such metacommunication teachers do exercise various forms of control over the ongoing state of classroom discourse (p. 158).

But to serve the purpose of modification as opposed to control, in the sense discussed earlier, one must bring to the fore a metapurpose. Consistent with the previously mentioned upshot for the learner this metapurpose is to make the teaching/learning discourse such that it may be possible for the learner to learn, thereby minimizing the difficulty of a subject matter for one's students. The primary metacommunication accompanying such a metapurpose in teaching discourse is the signal that the teacher is incessantly striving for what will be termed consensuality.

In the following section the concept of consensuality as a pedagogic concern, and its antecedent conceptions termed consensibility and commonality of frame of reference, are explicated through John Ziman's communal knowledge model of science. Also, the concept of pedagogic commensurability, as employed in the present study, is defined.

Consensuality, Consensibility, Commonality of frame of reference and Commensurability

Consensuality and Consensibility in Teaching Discourse

In developing a communal knowledge model of science, Ziman (1968, 1978) points to the inherent character of science as "public knowledge" (1968, p. 8), and conceptualizes the goal for the scientific community, therefore, as the development of "a consensus of rational opinion over the widest possible field" (1968, p. 9; 1978, p. 3). "In its simplest form" the communal knowledge model for science "consists of a number of independent scientists, linked by various means of communication" (1978, p. 6) about scientific knowledge. The latter refers to "the contents of messages that accumulate and are available in the public domain" rather than personal knowledge acquired by individual scientists and retained in their respective memories and thoughts (1978, p. 6).

Ziman reminds us that although, according to his model, the goal of science is to achieve the maximum degree of consensuality, "only a small proportion of the whole body of science is undeniably consensual at a given moment" (1978, p. 6). He then develops the notion of consensibility in characterizing those contents of scientific knowledge that have not yet contributed to the scientific consensus. By a consensible message Ziman means that the "message should not be so obscure or ambiguous that the recipient is unable to give it whole-hearted assent or to offer well-founded objections." A consensible message has a potential but has not yet become a consensual statement. The latter "has been fully tested and is universally agreed". According to Ziman, consensibility is a necessary condition for any scientific communication and hence for achieving consensuality regarding the contents of the communication (1978, p. 6).

In a somewhat analogous way the concept of classroom teaching/learning as communicative system envisages a linkage between the teacher and his/her students through teaching/learning as communicative processes. And the knowledge of a subject matter imparted and acquired by the participants, respectively, refers to that knowledge that is available to the participants (and observers) through the contents of the utterances of the classroom discourse.

Just as the goal of the scientific community is to achieve the maximum degree of consensuality, so also the classroom community, in order to achieve its intended objective, must incessantly strive for consensuality regarding the concordance between teaching and learning. However, considering the unequal-power nature of the classroom discourse as stated previously, the onus to seek consensus rests with the teacher.

Not only that, in addition teachers must, as a pedagogic pre-condition to consensuality, ensure the consensibility of their teaching utterances. To be consensible, an utterance in a discourse must be audible, linguistically intelligible, and cognitively comprehensible to the participants in a discourse.

Commonality of Frame of Reference in Teaching Discourse

For a teaching utterance to be pedagogically consensible yet another prior need must be fulfilled--"the need to move slowly forward, step by step, from a basis of generally accepted ideas" (Ziman, 1968, p. 28). As Ziman puts it, apart from "power to conceptualize," "a common metaphysic" is necessary for consensible knowledge. "Those who participate in the consensus must already share many beliefs" (1968, p. 38), and must "agree on a great many things if they are to come to agreement on something more" (1978, p. 16). "For successful intersubjective discourse, various principles must already be agreed between the participants. Communication is fruitless between scientists that do not largely share a categorical framework. The very idea of striving towards consensus implies that it must already be achieved in some respects--that certain issues are no longer considered worthy of questions" (1978, p. 21). And so too in classroom discourse, if consensibility and ultimately consensuality are to be achieved between the teacher and students, there must be a common frame of reference incorporating a common viewpoint regarding the subject matter of the teaching/learning discourse. This is what is meant by a commonality of frame of reference, and in view of the asymmetric power structure of the classroom communicative system as envisaged for this study, the responsibility for ensuring this commonality of frame of reference resides in the teacher.

Commensurability of Teaching Discourse

Another of the responsibilities of teachers that we must consider from the perspective of pedagogic integrity, is that of ensuring that the subject matter of the teaching discourse is in accordance with the requirements of the course, the structure of the curriculum, and the nature of the discipline. Such a concern for discourse-topic is referred to in this study as 'commensurability'. In this regard, the question for the teacher is whether the level of abstraction is appropriate to the dimensions of the problem at hand and is consistent with that dictated by the course and the curriculum. Further, the teacher must consider whether the details are sufficiently accurate, in view of the nature of the discipline, to understand the matter at hand (Ziman, 1978, p. 84).

Summary: Emergent Analytic and Methodological Orientations

To summarize, then, the following analytic orientations for the present study emerge.

Viewpoint for Analyzing the Discourse

Classroom teaching/learning discourse is to be viewed predominantly as a verbal communication system with an asymmetric power distribution, such that the onus for guiding the discourse towards its desired objectives rests with the teacher. In such a system the teacher must communicate with the students about the subject matter in such a way that it may become possible for the students to learn that subject matter.

There is a dynamic triadic relationship among teacher, learner, and the subject matter within a classroom teaching/learning communicative system. Teachers need to employ metacommunicative utterances for the purpose of modifying their teaching discourse and, thus, to serve the metapurpose of minimizing the 'difficulty' of their discourse and thereby increasing the possibility for their students to learn the subject matter of the discourse.

The metacommunicative utterances with such an underlying metapurpose are those that are concerned with (a) the consensuality of teaching discourse, (b) the consensibility of teaching utterances, (c) commonality of frame of reference, and (d) commensurability of the subject matter content of the teaching discourse.

The Methodological Orientation

Classroom teaching/learning discourse is examined in order to determine the form and function of the above mentioned metacommunicative utterances in teacher talk. The methodological orientation, as discussed in Chapter One and implied in Chapter Two, is encapsulated in the phrase 'evidential demonstration within the discourse'. This phrase implies that the particular form and function of a given metacommunicative utterance can be so determined and described only within the context of the appropriate episode within the entire discourse. In other words, the form and function of an utterance are determined not only by the content of that utterance, but also by the content of the preceding and succeeding utterances and, from a broader perspective, indeed by the entire discourse. Such a methodological orientation suggests a sequential analysis of the utterances within a discourse, and is in sharp contrast with "Interaction Analysis Systems" that ignore the context, emphasize the overt and concentrate on the measurable (Hamilton and Delamont, 1974, p. 4). The importance of context in studying teaching has been emphasized by other researchers as well (e.g. Powell, 1979).

One final note: although classroom teaching/learning discourse is analyzed in the present study, no attempt is made to conduct "Discourse Process Analysis" of the sociolinguistic ilk as is conducted by, for example, Heyman (1983), Grimshaw (1982), Merritt (1982), Gearhart and Newman (1980), Heritage and Watson (1980), French and MacLure (1979), and Corsaro (1978), etc. The analysis in the study may be similar to that conducted by above mentioned investigators in some respects. This may be especially true in respect of sequential examination of utterances in a discourse and in attaching singular importance to the context of an utterance in the present study. But the analysis differs significantly in the conceptions employed for attributing meanings and purposes to utterances of interest. The analysis also differs in its objective. The concern in the present study is not with the construction of social reality in classroom through verbal interaction; interesting and useful though that knowledge may be. The investigative concern, instead, is pedagogic and specially the problematic of the cognitive difficulty of a teaching discourse or its subject matter.

Whereas the analytic orientation provides a lens to focus on the relevant features of classroom communication, the methodological orientation suggests a way to describe the same. This is illustrated by analyses of chemistry classroom teaching discourse in the next chapter.

CHAPTER FOUR

Analysis of Chemistry Classroom Teaching

In this chapter is reported an analysis of senior high school chemistry classroom teaching within the perspectives of the analytical orientations and methodological considerations as explicated in earlier chapters. This report is divided into four sections. In the first section is given a brief and straightforward description of how the data of the teaching discourse were obtained. The second section then deals with the specific objectives and methodological considerations for the conduct and description of the analysis. The analysis itself is presented in the third section, and the conclusions drawn from the analysis are summarized in the fourth section.

Procurement of Discourse Data

The data for the present study were obtained in March 1983 by observing and audiorecording verbal interactions during chemistry classroom teaching. The lessons recorded are from the classrooms of three different teachers at three different schools, including lessons from all three senior high school grades (10, 11 and 12). Except in the case of one teacher, more than one class taught by the same teacher is included. For all three teachers, several sessions of a given class of students were observed and recorded.

The observation and recording were done over an extended period of at least one week for each class. The investigator spent a little more than a three-week period in the classrooms. The presence of the investigator and his audio-cassette recording equipment for an extended period was considered desirable in the interest of minimizing the artificiality of the situation and maximizing the naturalness of the classroom teaching/learning discourse.

The recording was done using a pocket-size portable audio-cassette recorder with two extended mini-microphones. All three classrooms were combination lecture-laboratory rooms, each with its own unique floor plan. In one of the classrooms, the investigator sat at the side laboratory table on which his recording equipment was also set up. In another classroom the investigator with his recording equipment occupied a couple of desks in the middle of the room. In the third classroom the investigator along with his recording equipment alternated between the side laboratory table and the desks in the middle of the room, from session to session. During the observations the investigator was mainly concerned with noting down the 'board work' and any other non-audio aspects of the interaction--silent responses, for example--that were considered relevant for the study.

The three teachers involved are very well known to the investigator personally, and have at one time or other been his close professional colleagues. Their teaching experience varies from a low of four to a high of more than thirteen years. They, along with some other colleagues, were approached to participate in this study. These three teachers willingly consented, despite the fact that they were given very little information as to what the study was all about, save that the present investigator wanted to observe and record their classroom teaching discourse as it naturally occurs. Their willingness under these circumstances underscores the normality and the naturalness of the discourse data. The students were also given as much information by these teachers as the latter had received, i.e., very little. However, the students were assured both by their teachers and by the investigator that they were not the focus of this study. In one school the students recognized the investigator as a former teacher. In the other two schools the investigator was introduced as a teacher and the students accepted him as such. This became evident as on occasions the investigator, at the invitation of the teacher, joined in the teaching/learning discourse. This acceptance of the investigator by the students further emphasizes the normality and the naturalness of the discourse data. In the case of students from one of the three schools involved, it was considered necessary by the school administration to obtain prior parental approval. It was sought and obtained by the teacher for all students involved.

At appropriate moments during sessions such as students' laboratory work, seat work, or during interruptions in the normal teaching/learning discourse, as well as after the lesson discourse, the investigator often quizzed the teacher and students in order to seek clarification of various relevant aspects of the discourse from their perspective. Two of the three teachers were formally interviewed in this regard. Although these quiz and interview data are not systematically analyzed here, they nevertheless provided the investigator some valuable insights into the phenomena from the perspectives of students and teachers as well as indirect confirmation of some of the inferences drawn from the analysis.

Objectives and Methodological Considerations for the Analysis and the Format of its Description

The purpose of this section is simply to orient the reader to the investigator's frame of reference for the analytic inquiry. Hence, included in this section are rather crisp and summary statements only, concerning the objectives and certain methodological considerations for the analysis. These are followed by a brief description of the format of the report of the analysis.

Objectives for Analysis

The main objective of the analysis as conducted for the present study and reported later is to demonstrate the occurrence of certain specific pedagogic tactics embodied in some metacommunicative teacher utterances within senior high school chemistry classroom teaching/learning discourse. The pedagogic tactics of interest are those that reflect teachers' concerns for consensuality of their discourse, consensibility of their teaching utterances, and commonality of the frame of reference with their students; and for the commensurability of the subject matter of their teaching discourse with course requirements, curricular structure, and nature of the discipline.

Subsumed under the aforementioned main objective for this analysis are three subsidiary, nevertheless significant, purposes implicit in the analysis. The first is to bring out the salience of the conceptions of pedagogic consensuality, consensibility, commonality of frame of reference, and commensurability as features of teaching/learning discourse. The second is to emphasize the importance of these conceptualizations in understanding the 'difficulty' of the subject matter of a teaching/learning discourse. The third is to demonstrate the power of a fresh way of looking into pedagogic problematics, both as a way to seek appropriate remedies and as a means to gain further insight into the phenomena of teaching.

Methodological Considerations for the Analysis

The 'fresh way of looking' at the pedagogic phenomenon of interest in the study is, first, to consider teaching as a communicative process and classroom teaching/learning as a communicative system, as explicated in Chapter Three. But it is also to look at the salient features of the phenomenon within the 'contextual gestalt' as defined in Chapter One. Within this view, one does not see, for example, an utterance as an isolated self-contained unit unrelated to the rest of the discourse. Instead, a particular utterance receives its full meaning only in the immediate context of an episode, and only in terms of its relative position within a specific episode of a particular discourse. Moreover, the meaning that we as observers (and the participants as well) ascribe to a particular utterance is within the general framework of our (and the participants') intuitive knowledge of the 'discourse type'. As Stubbs points out,

> there is no reason why the linguist-researcher should be afraid to use his intuitive knowledge of the system of communicative behaviour in order to work out its structure. Indeed, there is, in principle, no way of inducing the systematic significance of fragments of behaviour, without making use of the tacit knowledge of the system held by a

> native or near native member. It would be impossible to set up an automatic procedure which would allow one to induce the rules for appropriate behaviour in a given speech community, without the privileged access to the meaning of the speech held only by someone with intuitive knowledge of the system. (Stubbs, 1976, p. 156)

Our intuitive knowledge of a phenomenon generates tacitly held, nevertheless clear-cut, ideas that initially guide the explorations of that phenomenon. The phenomenon, in turn, drives these ideas from their initial tentative status as mere intuitions toward more tenable, empirically founded, conceptions with power to generate deeper understanding of the phenomenon. Such a reflexive interaction between a phenomenon and its intuitive understanding helps reveal the intrinsic salience of a particular set of features inherent in the phenomenon. In such a view of unfolding of a discourse, the concern is with understanding various recurrent utterance patterns as they constitute the discourse. Such understandings provide us with fruitful guides for our attempts at remedying the problematics of individual teaching/learning situations.

The Report Format

In the next section, selections of transcribed text of the audiotaped chemistry classroom teaching discourse from diverse lessons are interspersed with the investigator's comments throughout the report. The text of the investigator's comments consists of description, interpretation, inference, and summary-conclusions. A distinction between transcribed text and investigator's comments is effected by single-spacing the transcribed text within wider margins. Each excerpt of the transcribed text is designated by a letter--A, B, C, etc., and each utterance in the excerpt is numbered--1, 2, 3, etc. An utterance is regarded a composite of all that a particular participant says (speech sense) before another participant takes over. At times there are overlaps and other complications illustrative of natural conversations. These are dealt with appropriately as and when they occur. For example, 'silent responses' are transcribed simply as such, i.e., by a blank after indicating the respondent(s). Long monologues considered irrelevant to illustrate a certain analytic comment are condensed thus, "you know last night . . . but now let us get back to work," etc. The following abbreviations are used to designate various participants in the discourse:

I = investigator
T = teacher
St. = an unidentified student
Sts. = several students or 'the class'
L, Lo, Ji, Jo, etc., = an identified student

Throughout the text of the investigator's comments, the excerpts are referred to by their letter and utterances by their number. Appropriate utterances and/or parts thereof are underlined in order to indicate the evidential illustration of various analytical comments.

The Analysis

Introduction: Metacommunicative Utterances

T: "O.K. . . . O.K. . . . aa . . . how are we feeling? Everybody happy?"

How shall we 'hear' utterances such as the one stated above in the middle of a senior high school chemistry lesson? Is this, in the form stated above or in various other versions, a familiar or commonly occurring type of teacher utterance in classroom teaching/learning discourse? And if so, what pedagogic purpose(s) are such utterances to be 'heard' to serve? Similar questions were asked of a teacher whose classes were observed and audio-taped. The following is an excerpt from that interview:

Excerpt A

1. T. O.K. I think when you say something like that it's aa . . . part of aa . . . the aa . . . job of keeping the kids . . . keeping the kids with you.

2. I. But the phrase you used "keeping the kids with you" . . . aa . . . would you then suggest that aa . . . this is one of the things that teachers always . . . you know . . . keep in mind and make provisions that the kids are always with you? In . . . In other words they are in the same frame of reference and aa . . . keeping to the objective of the lesson?

3. T. Well I . . . I . . . I . . . I . . . I just don't . . . can't imagine how you'd be a successful teacher if you didn't.

4. I. If you didn't do that. Yes.

5. T. Yes.

And how are we to interpret the phrase "a successful teacher" in #3 in the above excerpt?

In pedagogic discourse, certain metacommunicative utterances appear to function repeatedly for the guidance and continuance of a viable teaching process. These utterances embody certain pedagogic tactics that teachers employ all through their teaching discourse. We say only this much here, simply to indicate the type of utterances that are examined in this analysis. We shall let the transcribed text of the teaching discourse elucidate the form and function of these pedagogic tactics, as embodied in various teacher utterances. It must be emphasized, however, that the phrase "a successful teacher" in #A-3 does bring to the fore a metapurpose of all such pedagogic tactics, which is an 'upshot' of a teaching process for a learner--making it become possible for a learner to learn what is being taught.

As mentioned earlier, the pedagogic tactics of interest are those that reflect a teacher's concern for 'consensuality', 'consensibility', 'commonality of frame of reference', and 'commensurability'. We shall examine selections of transcribed text of the teaching discourse for these tactics in the same order. Thus, the first set of pedagogic tactics considered is termed, simply, the Consensuality Check. (The term 'check' is used, as appropriate, with its implied notions of determining if something is as it should be, as well as soliciting feedback for modification. Next comes the Consensibility Check and so forth.

In order to demonstrate the non-idiosyncratic occurrence of these pedagogic tactics, appropriate excerpts from classroom discourse of all three grade levels--10, 11, and 12--are included in the analysis. Excerpts at different grade levels are from the classroom discourse of different teachers. And one final note: before an excerpt is analyzed, a brief contextual background of the excerpt is provided.

Consensuality Check

Concern for consensuality emerged from the analysis as a strikingly persistent feature of the teaching discourse of all three experienced teachers whose teaching was observed. The investigator begs the reader's indulgence through the rather long and detailed account which follows and which is required to permit the identification of consensuality checks in context. The account of the analysis is presented in three sub-sections, one for each teacher (labelled as Teacher I, Teacher II, and Teacher III).

Teacher I. We first go to an excerpt from a chemistry lesson in Grade 10*. This is a lesson in a continuing unit on writing balanced chemical equations and recognizing a chemical reaction type from its description. Immediately prior to this unit the students had completed a unit on writing chemical formulae of chemical elements and compounds. After this unit the class will be learning to determine amounts of substances involved--reacted and/or produced--in chemical reactions. In this particular lesson the students were about to take a mini-quiz**, when some students raised certain concerns regarding the topic and the assignment of the lesson in the previous period. The teacher decided to attend to those concerns first, before giving the mini-quiz.

---

* Readers not familiar with the Alberta curriculum should note that sequential chemistry courses are offered in Grades 10, 11, and 12 in the secondary school. These are called, respectively, Chemistry 10, Chemistry 20, and Chemistry 30.

** The mini-quiz itself is, of course, a teaching strategy that some teachers employ to guide the progress of their teaching program.

Excerpt B

1. T. On the very first point. Hydrocarbon combustion should be one of the easiest ones to pick out. Lana, you asked me about it too. If you go back again and look at how it is described on the original page there, page nine, hydrocarbon combustion always has some hydrocarbon, it always has oxygen. Those are the reactants, and then the products are always the same: carbon dioxide and water. So when you see one that has a hydrocarbon and then a plus oxygen, then you end up with carbon dioxide and water, then you know that it is hydrocarbon combustion. Aa . . . And which ones were they? We had that.

2. Sts. Fifteen and . . . (inaudible) . . . thirteen . . .

3. T. Fifteen. Right. Notice this is methane and oxygen, and thirteen is propane and oxygen. I wouldn't expect you to know the names of those hydrocarbons* but can you see the pattern there, Lana?

4. L. ________________

5. T. Carbon-hydrogen compound, then the oxygen, and always the same products: carbon dioxide and water. That's how you pick it out. O.K. Getting back to this business here for a minute, balancing, you have to keep in mind the fundamental premise upon which this is based. O.K. and what is it? . . . What are we really trying to do in balancing?

We 'hear' in #B-1 the teacher orienting himself to the first of the concerns raised by students, especially by Lana. He then proceeds with the teaching utterance. Then in #B-3 he inquires of Lana whether she herself, as an individual student, could see the pattern he is trying to emphasize for the class as a whole in #B-1. We say 'class as a whole' because #B-2 is attributable to several students. Although we do not hear a verbal response by Lana in #B-4, a crisp repetition of the emphasized pattern by the teacher in #B-5, punctuated by a 'closure-type' "O.K." as evidenced by his move toward a different student concern, leads us to infer that the teacher 'hears' Lana's 'silent response' in #B-4 as 'she can see the emphasized pattern'. Thus in #B-3, we 'hear' through "But can you see the pattern there Lana?" evidence for the teacher's concern for consensuality with Lana, that is, for the concordance of his teaching and Lana's learning.

---

* The phrase "I wouldn't expect you to know the names of those hydrocarbons" in #B-3 reflects a different concern (commensurability) that we will let the discourse data elucidate later on in the analysis.

'Silence as a response' at such junctures as, for example, the teacher's consensuality-check (either with an individual student or with the class as a whole) is itself a problematic. How shall we 'hear' such 'silent responses'? By and large, and as indicated to this investigator by teachers and students alike, such silent responses are taken to mean affirmation of understanding and/or absence of any further need on the part of the students to question and prolong the episode. This is, however, by no means always the case. For, the text of the discourse if pursued long enough will always reveal how a particular 'silent response' was 'heard' by a teacher. So, we pursue this discourse a little further.

Excerpt B (continuing)

6. St. You have the same number of atoms on either side.

7. T. That's right. We're just trying to recognize that we have to have the same number of atoms here in the reactants as products. Because remember what a chemical reaction is? It's a

rearrangement of atoms. Right? Remember the definition Lori?

8. Lo. ________________

9. T. A rearrangement of atoms. Now if you've got a little box of atoms and you rearrange them, you didn't take any out or put in, that's really what we're thinking about. Yes Steve?

10. S. I was just wondering. Where do you start? That's what my . . . (inaudible) . . .

11. T. O.K. . . . ahm . . . There are certain little tricks of the trade, I have to recognize that you learn as you get more experience with this. And sometimes I have been doing it for so long I don't remember what they are myself . . . ahm . . . I just automatically do it. But we find, I think we find it that . . . aa . . . it is best to start with atoms other than hydrogen and oxygen first, and go to the hydrogen and oxygen last, if you can. That usually works . . . (inaudible) . . . Also, another trick I mentioned the other day is, you have a group, complex ion like phosphate ion and ammonium ion, it's best to deal with them as a group if you can see that they appear on the other side of the equation and they haven't been broken up. So notice that we have the ammonium ion over here and we also have the phosphate ion so, we can treat them as though they were single atoms and balance them as a complex ion . . . (inaudible) . . . so many phosphate groups, and then we can deal with the other atoms separately. Does that make any sense to you?

12. S. Yes (barely audible).

13. T. Lori, do you know what I'm talking about there?

14. Lo. ________________

We notice here that the teacher has moved on to a different discourse topic and does not return to Lana but, instead, goes to Lori in #B-7. Lori, in #B-8, gives a 'silent response'. How do we 'hear' and, more importantly, how do we 'hear' the teacher 'hearing', that 'silent response'? We notice that in #B-9 the teacher goes to Steve. It may be that Steve has successfully drawn the teacher's attention to his (Steve's) own concern. This is evidenced by a rather long utterance by the teacher in #B-11*. But later in #B-13 we notice that the teacher goes back to Lori with a very explicit consensuality check, and again receives a 'silent response' from her in #B-14. We continue with our analysis of subsequent utterances in this discourse.

Excerpt B (Continuing)

15. T. So let's go ahead and deal with the phosphate ion first, O.K.? How many do we have here? [Pointing at "$(NH_4)_3PO_4$" in the unbalanced equation written on the board: "$H_3PO_4 + NH_4OH \rightarrow (NH_4)_3PO_4 + H_2O$"]

16. St. One. St. One.

17. T. One. And how many over here? (Pointing at "H_3PO_4" in the equation)

18. St. One. St. One.

19. T. One. So we don't have to make any adjustments there, right?

20. Sts.

21. T. Now what about ammonium? How many ammonium groups do we have here? [Pointing at "$(NH_4)_3PO_4$"]

22. St. Three.

23. T. Three of them. Everybody see that?

---

* The utterance #B-11 itself culminates in another type of pedagogic tactic--the cognitive consensibility check--that we shall elucidate later in the analysis. Another example is at #B-23, which also includes an auditory consensibility check.

24. St. Yes.

25. T. Three ammoniums? And so we . . . how many do we have here? (Pointing at "NH_4OH")

26. Sts. One, one, one . . .

27. T. So that means we have to put a big 3 there, (indicating before "NH_4OH") right? Now we've got three ammoniums . . . now that means that we've got to have three hydroxides as well, right? Nor . . . normally it's very helpful in chemistry if you think about water sometimes as being hydrogen hydroxide (replacing "H_2O" with "HOH" in the equation). . . . You can think of it as . . . aa . . . being a combination of this hydrogen and hydroxide (pointing at "H_3" in "H_3PO_4" and "OH" in "$3NH_4OH$") group and that helps us to balance a little because you can see we've got three hydroxide, so how many are we going to have to have?

28. Sts. Three, three . . .

29. T. Three (writing "3" coefficient before "HOH"). And, of course, notice three hydrogens besides, right? Which just fits in nicely there, doesn't it. And that, that does it.

30. St. What happens if it didn't fit?

31. T. Pardon me?

32. St. What happens if it didn't fit?

33. T. Well somehow it always does in the end. It has to. So when you get down to those last few numbers very of . . . often you'll find that, yes, when you put that last number in you needed it for two reasons. Now did that help at all Lori?

34. Lo. (inaudible)

35. T. O.K. What . . . what is it that . . . aa . . .

We observe here that the teacher is continuing with the same discourse topic with the class as a whole, apparently disregarding Lori*. But we find him again with Lori at #B-33 making another attempt to check consensuality. It is evident that Lori's 'silent responses' at #B-8 and #B-14 were 'heard' by the teacher neither as affirmation of her understanding of the discourse topic, nor as her request for a cessation of further explication of the topic on the part of the teacher. This becomes abundantly clear when, in response to a barely audible utterance by Lori at #B-34, the teacher in #B-35 comes right out with it and asks what is it that is plaguing her. As the discourse continues we see an illustration of a very considerably prolonged episode (#B-36 - #B-86) for the sake of consensuality with this individual student. (Such is the apparent strength of the quest for consensuality.)

Excerpt B (Continuing)

36. Lo. I don't know where. . . I don't get it . . . like . . . O.K. do number four.

37. T. O.K. Number four is aluminum, . . . aa . . . or pardon me, arsenic chloride and hydrogen sulphide. Maybe I should let you help a little more on this one so that . . . aa . . . O.K. What kind is it going to be, as soon as you look at the two reactants? Lana what do you know? What do we have here?

38. L. Compound . . .

39. T. Compound . . .?

40. L. Compound.

41. T. Right on! Compound compound so what's it going to be?

---

* We note the occurrence of an auditory consensibility check through #B-21 to #B-25 (to be elaborated later in the analysis) and again through #B-28 and #B-29.

42. L. Double replacement. St. Double replacement.

43. T. Double replacement, isn't it? So we have to think in terms of, you know, . . . aa . . . switching the positive and the negative . . . aa . . . of course you know how to do that in this exercise. It's going to be arsenic with sulphur right? And it's . . . a . . . As_2S_3 and HCl. I think I made a mistake . . . (laughs) . . .

44. St. (laughs)

45. T. All right now Lori. We'll let you get involved in this one now. How would you start? What do you start with? (Unbalanced equation on the board shows "$AsCl_3 + H_2S \rightarrow As_2S_3 + HCl$")

46. Lo. (inaudible)

47. T. Which one are we going to work on?

48. Lo. That's what I . . . (inaudible) . . .

49. T. O.K. that, maybe that's the problem. You just choose . . . (inaudible) . . . it's just up to you which one you want to start on first. Just pick one, whatever one you want. You have to start somewhere. Which one do you want to start with?

50. Lo. Arsenic . . . (inaudible) . . .

51. T. Arsenic?

52. Lo. Yes.

53. T. Remember we can only do one element at a time. We don't do the whole compound. O.K. how many do we have? (Pointing to reactant "$AsCl_3$" in unbalanced equation on the board)

54. Lo. One.

55. T. And how many do we have? (Pointing to product "As_2S_3")

56. Lo. Two.

57. T. All right, what are we going to do?

58. Lo. Two there. (Pointing to reactant)

59. T. Right. O.K. (Enters "2" coefficient before "$AsCl_3$" on board) Now we got that fixed. What do you want to do next?

60. Lo. The hy. . . gen . . . the chloride.

61. T. All right. How many do we have here? (Pointing to "$2AsCl_3$")

62. Lo. Three.

63. T. No.

64. Lo. . . . (inaudible) . . . that?

65. T. Six.

66. T. And how many do we have there? (Pointing to product "HCl")

67. Lo. One.

68. T. So what are we going to do?

69. Lo. Put a six.

70. T. Right. O.K.? (Enters "6" coefficient before "HCl" on board) What do you want to do next?

71. Lo. The hydrogen.

72. T. All right. How many do we have there? (Pointing to reactant "H_2S")

73. Lo. Two.

74. T. How many do we have there? (Pointing to "6HCl")

75. Lo. Six.

76. T. So what are we going to do?

77. Lo. Put a three in front.

78. T. (Enters "3" coefficient before "H_2S" on board) O.K.? What do you want to do next?

79. Lo. It's done.

80. T. No. It's not done. You didn't do sulphur.

81. Lo. Oh. Oh. You have to . . .

82. T. How many sulphurs do we have here? (Pointing to "$3H_2S$")

83. Lo. We've, we have three.

84. T. Is three . . .

85. Lo. Yes.

86. T. O.K. Now you . . . maybe you already noticed it. It was done. But you have to mentally count them so . . . if you know that you checked it, in other words you have to check every atom mentally and we hadn't up here so, you noticed it. So you have . . . (inaudible) That's all you do. You just pick one and do it, pick the next one and do it, pick the next one and do it, keep going. Now, if it doesn't work out and you run into a blind alley, then you have to go back and try some, something else. Sometimes things get a little more hectic than what we have right here. So . . . aa . . . how do you feel about that?

The episode culminates, of course, in a consensuality check with Lori regarding the concordance of the teacher's teaching and her learning. We 'hear' it in #B-86 thus, "So . . . aa . . . how do you feel about that?" Further, in this metacommunicative utterance we not only 'hear' the concern for consensuality, but also we see the metapurposive concern come to the surface: "Have I been able to make it less difficult for you, Lori?" or, "Have I been able to communicate with you so that it is now possible for you, Lori, to learn what I have been trying to teach?".

We 'hear' the subsequent utterances #B-87 - 91 in the following section of Excerpt B not only as good natured mutual congratulations but also as affirmation of consensus regarding the concordance between what is being taught by the teacher and what is being learnt by Lori. This is further evidenced by #B-92 in which the teacher returns to the class and seeks their consensus as well, with "O.K. any other questions?" Thus,

Excerpt B (Continuing)

87. Lo. O.K.

88. T. I think you know what you're doing, because there's no . . . you know, I didn't want to be . . . aa . . . (coughing, inaudible) . . . what you said. But there's no way that you could . . . aa . . . be lucky enough to get all those coefficients right, unless you knew what you were doing.

89. Lo. Well, I have the first first nine right and then I thought (coughing, inaudible) . . . like that . . .

90. T. (laughs) So you were doing it right.

91. Lo. Yes.

92. T. O.K. any other questions?

We say that the teacher returns to the class, because now another student becomes engaged with him in a rather brief episode, below in #B-93 - 99. The teacher seeks the consensus of the class again in #B-100, apparently finds it in the nonverbal expressions of the class, and proceeds with the planned activity--the mini-quiz.

Excerpt B (Continuing)

93. St. When it has a multiplication sign in number five, does that count as one compound?

94. T. That's still one big thing. Yes, and we can treat it, we have to treat it as one (coughing) . . . compound.

95. St. O.K.

96. T. You can't change the five in the middle there. These hydrates, you're talking about the hydrates?

97. St. Yes.

98. T. Yes . . . aa . . . you know, with the hydrate we can't . . . aa . . . change the number that is in as part of the hydrate, can we? That's really a special kind of formula that has a coefficient right in the middle of it. It's the only example you have where you can use a coefficient right in the middle, and that has to remain so when you treat that. You have to, just like everything else you can put a number in front of it. That's all. Was that, was that your question Mar . . . ?

99. Mar. uhun . . .

100. T. O.K. . . . O.K. . . . aa . . . how are we feeling? Everybody happy? Let's have a little quiz really quickly there just close your books and aa . . .

Teacher II. We turn next to an excerpt from the discourse of a Chemistry 20 lesson by another teacher. The class has completed a review of the Chemistry 10 course, and has written a test on the review material in the previous period. In preparation to begin the Chemistry 20 course material, the teacher gave the students a reading assignment in the previous session: to read the first two pages (G1 and G2, as called out in the discourse) in a unit on chemical bonding. Now, in the present period, they have just finished a post-test discussion.

Excerpt C

1. T. We are gonna . . . aa . . . move on to the next chapter, and you take your books and turn into . . . aa . . . section G and we'll start talking about bonding.

(Students talking amongst themselves, some with the teacher, a lot of good natured talk; some are still talking about marks in the test, some about the new topic--bonding)

2. T. O.K. Chapter Two. Is there a problem there? (Students still talking amongst themselves) Yes? No? O.K. . . . aa . . . Last day I asked you to start reading G1 and G2. Very quickly, what I would like to do is to go over G1 and G2, then we'll mark the little chart. And then we are gonna see how else we use this tool. The new tool that we are using is called the Lewis dot diagram, and just as a review I'd like to go over and talk about, say for chlorine, the electron energy level representation for an atom of chlorine . . . (indistinct). What is the (indistinct) required for that?

3. St. The . . . aa . . . atomic number.

4. T. O.K. And what does the atomic number tell you?

5. St. The number of protons.

6. T. O.K. Do you have to know what . . . aa . . . chlorine's atomic number is?

7. Sts. Seventeen. Seventeen.

8. T. If (inaudible) in the atom form, how many electrons would it attract?

9. St. Seventeen. Seventeen.

10. T. And how many would go in first?

11. Sts. Two.

12. T. How many would go in the second?

13. Sts. Eight.

14. T. How many would go in the third?

15. Sts. Seven.

16. T. O.K. This is the electron energy level representation. This is the old way of representing atoms (pointing to his 'board-work'). There is another way to represent atoms and it's called (writing on the board) Lewis . . . . So, now, we are going to learn a new scheme or a new way to represent atoms, and eventually use those to represent molecules, also and with the little change . . . ahm . . . finally get to the . . . aa . . . diagram which is called structural diagram. For chlorine if we are to do a Lewis dot diagram we do not include the inner energy-levels. The only thing we are concerned with is . . . aa . . . the outer energy level, and I am not too sure if I drew a diagram for you what molecular model should look like. I said don't worry about . . . aa . . . what I am doing when we (inaudible) we would make things more understandable to you . . . aa . . . later on but what I am going to do is to go back to this electron configuration. I don't know if you remember I put a nucleus here and I said that (writing on the board) that there is the first energy level and did I tell you what shape it was? What was that all about?

17. Sts. It was . . . (inaudible) . . .

18. T. And I said the first energy level which is spherical . . . aa . . . Remember we got to think three dimensionally now . . . aa . . . how many electrons does it take to fill it?

19. Sts. Two. Two.

20. T. Second energy level starts with what type of . . . aa . . . orbital?

21. Sts. (inaudible, soft-spoken)

22. T. It is also spherical and how many does it take to fill that?

23. Sts. Eight. Eight. Two. One . . .

24. T. And remember I said that within the second energy level there are actually four sub-orbitals, and when I say . . . aa . . . second energy level the first energy lev . . . or orbital is spherical shape the next one, does anyone remember what they were?

25. Sts. (inaudible)

26. T. They are pear shaped or propeller shape, and there's three of those the "x" the "y" and the "z". How many does it take to fill the "x"?

27. Sts. Two.

28. T. "y"?

29. Sts. Two.

30. T. "z"?

31. Sts. Two.

32. T. Similarly we would continue on in the third energy level. There's the "s" which takes two, there is also the "$P_{x,y,\text{ and }z}$" each taking two. Therefore that's how we got this (pointing at the board-work) for the elect . . . electron energy level representation. We said for the first energy level it took two to fill, for the second energy level takes . . .?

33. Sts. Eight.

34. T. Eight to fill. The third energy level takes . . .?

35. Sts. Eight.

36. T. . . . eight to fill, and we drew the picture . . . The first energy level takes two, the second energy level not only includes the spherical one but the "$2p_x$" and the "$2p_y$" and the one coming at you the "$2p_z$". Each of those taking two to fill and similarly when you get the third energy level and got the . . . aa . . . "s" which is two, the "3ps", "x," "y," and "z" which makes a total of eight to fill. Everyone O.K. up to there?

37. Sts.

38. T. When you draw the Lewis dot diagram you don't include the inner energy levels. You only include outer energy levels or the valence energy level . . . However, which energy level we're talking about here? (pointing at the board-work regarding chlorine)

39. Sts. (indistinct . . . third)

40. T. We are talking about the third energy level. Let's take a look at this within the third energy level. How many sub-orbitals are there?

Here we see the teacher's attempt from #C-2 to #C-16 to establish consensus regarding the concordance of what was taught and learnt thus far, concerning the representation of atoms. And we 'hear' in #C-16 his attempts at what sociolinguists might call 'formulating' the discourse topic, not only for this lesson but also for several subsequent sessions. However, our analytic interest lies in the demonstration of his concern for consensuality, within his teaching/learning discourse. We find the same implicitly in this episode. We say implicitly, because the class had just written a test on this material, yet the teacher begins the lesson for a new topic with a brief review of a prerequisite topic already studied (in Chemistry 10, and again reviewed in Chemistry 20). At this point, 'a brief review one more time', provides implicit evidence for the teacher's incessant concern for consensuality regarding the concordance between teaching and learning. And, we see explicit evidence for this in the teacher utterance #C-36, "Everyone O.K. up to there?". We cite this as an illustration of evidence for consensuality check, because the teacher then moves on to the new topic of the discourse.

Excerpt C (Continuing)

41. Sts.

42. T. Here's one, here's two, three . . . how many? (pointing at the board-work)

43. Sts. Four.

44. T. And now to do the Lewis dot diagram? What you do, you just represent the electrons in the valence energy level, or the outer energy level. And, you told me that the outer energy level in this case was the third energy level, which consisted of four . . . sub-orbitals. And, what you do to represent those is one of the sub-orbital is here one of them is here one of them is here and one of them is here (pointing at the diagram at the board) . . . How many does it take to fill any one of those?

45. Sts. Two.

46. T. Two electrons. How many do we have to put in for chlorine?

47. Sts. Seven. Seven.

48. T. We have seven in all to put in. You put one in here first, then one in here, then one in here, then one in here, then you double them up and how many do I have left? (pointing at the diagram on the board)

49. Sts. Three. Three. Three.

50. T. (teacher completes the diagram) So it would look like (teacher draws another diagram) . . . would look like this . . . Whenever you get . . . two electrons in a sub-orbital . . . there is a name given to those . . . , and that was part of your reading assignment. Does anyone know what they are called?

51. St. Lone pair.

52. T. Parry?

53. P. Lone pair (teacher writing on the board).

54. T. And whenever you only have one electron . . . do you know what's that called? (asking another student)

55. St. (inaudible), St. (inaudible)

56. T. No. Someone help out. Tom? . . .

57. T. No idea! Karen at the back?

58. St. Unpaired.

59. T. Kirk says unpaired I say no. Jackie?

60. J. Bonding electrons?

61. T. O.K. (writing on the board) So the new . . . the new tool we are going to use is called Lewis dot diagram. You write down the symbol of the element that you are trying to represent, and then you are only to represent the outer energy level, and in this case by using the electron energy level representation we said the last energy level starting to be filled is the third energy level in this case, and you . . . seven electrons that you have to represent. So we took those seven, wrote down the symbol of the element, and then we put one in each of the sub-orbitals, and then we descri . . . described the sub-orbitals here, and we said we put one in each first and then we doubled up. Then we gave these things some terminology (pointing at the board). Whenever there was two electrons in a sub-orbital we called a lone pair and whenever there was only one electron in a sub-orbital we called it bonding orbital. Is there any problem with this?

62. Sts. ______________

63. T. Let's now take a look at page G2 I believe it is . . . and they described the same exercise that we just did on the board (referring to Lewis dot diagram for a chlorine atom on the board). I like to just run through with everyone, and wherever there is a problem we would take it up on the board. And then, I want to talk about how to use electron dot diagrams for atoms, and show how we can put two atoms together still using [still using] electron dot diagrams to describe how you get the structure for a molecule. Jude?

And once again we see, but this time at the end of an episode, the teacher's concern for consensuality shown in #C-61, "Is there any problem with this?" We notice that at this point the teacher does not 'hear' students' 'silent response' as affirmation of understanding. This is evident in #C-63 in which he indicates a change in activity and not the topic of the discourse. But the contingency of the discourse demands that he attend to Jude's concern, first.

Excerpt C (Continuing)

64. J. What do they mean by valence orbital?

65. T. . . . aa . . . How many valence orbitals would we have to represent for chlorine?

66. Sts. Four.

67. T. For chlorine we have to represent a third energy level, and how many sub-orbitals are there in the . . . third energy level?

68. J. Four.

69. T. Four. So, how many valence orbitals does it have or how many orbitals are in the outer energy level?

70. J. Four.

71. T. Four. There is only one element . . . aa . . . that you have to be concerned with that will only have one. Do you know which one would that be?

72. Sts. Hydrogen (indistinct) . . .

73. T. Hydrogen looks like this and we know that in the first energy level there is only one sub-orbital there is only spherical one. Does that help you?

74. J. (indistinct)

Here, our concern is not with whether Jude has been helped through this episode. In fact we cannot answer this short of asking Jude directly. Our interest, however, lies in showing another illustration of the teacher's concern for consensuality, this time with an individual student (reminiscent of Teacher I's extended work with Lori). The concern is evident in #C-73, "Does that help you?", followed by a change in activity (but not topic) in #C-75.

Excerpt C (Continuing)

75. T. O.K. . . . aa . . . we will start with Val and we will go across the front row this time and we will start with number one. In fact, I'd do number one and what I want is you guys to do it. The atom is S which stands for sulphur, and the group that it is from? How do I find the group number? Kim, group number?

Teacher III. Finally, two rather short excerpts from a Chemistry 30 lesson are examined, taught by the third teacher. This lesson is in fact a post-laboratory discussion. The students have been studying in the laboratory various factors that affect rates of reactions. They will continue their study of reaction kinetics for several sessions to come.

Excerpt D is a portion of the class discussion of surface-area-of-contact as a factor and its influence on the rate of a reaction.

Excerpt D

1. T. O.K. So what we're looking at here IS as Nat suggested, that YES if you can get a reaction to occur in a homogeneous system, rather than the heterogeneous system, by increasing the surface area, the contact area between the molecules, you will in fact increase the rate of reaction. O.K.?

2. Sts. ________________

3. T. And we do take care here (writing on the board), in identifying the difference here in terms of what we mean by, by phase as compared to state. Because we can have two similar phases in contact, in contact with each other, two solids, two liquids that do not mix. Where there is only a layer or a surface contact between the two it still be heterogeneous. Whereas you get two similar states completely intermixed if you like, high exposed surface area . . . (inaudible) . . . two particles, then you have true single phase homogeneous reaction. Any question?

4. Sts. ________________

5. T. O.K. the last factor that we'll consider . . . Is there another factor? Can you give me another factor which you think it is possible to . . . (inaudible) . . . or decrease the rate of reaction, any reaction?

Here again we see evidence of concern for consensuality in #D-1, "O.K.?", and in #D-3, "Any question?". We note the use of "O.K.?" at the end of #D-1 as a consensuality check, in contrast to the habitual use of "O.K." at the start of #D-1 and #D-5. Also, we observe that the 'silent responses' by the class both at #D-2 and at #D-4 are indicative of affirmative understanding on the part of the students as 'heard' by the teacher. This is evident by #D-3 in which the teacher goes on to make a different point than what he made in #D-1; and by #D-5 in which he switches the discourse-topic.

Excerpt E forms the last set of utterance in the same discourse. The class has come to the end of the post-laboratory discussion.

Excerpt E

1. T. We'll find out . . . some of that you're going to discover for yourself . . . O.K. Nature of reactants, concentration temperature, surface-area--defining in terms of homogeneous heterogeneous reactions, and addition of catalysts are the major factors that we identified that slow the rate or increase the rate of reaction. All right. Your assignment then is to complete your lab. exercise first, primarily, and then into chapter two exercise seven and eight in the book . . .

2. Sts. (general chatter . . .)

3. T. Next week . . . (continuing with the home work assignment references) . . . we'll be looking at the theory behind in trying to account for reasons as to why these factors in fact affect the rate of reaction. And we're going to go into our small group discussions, and we're going to go our peer group presentations as I mentioned to you before . . . (continuing administrative comments. . .). Any questions?

4. Sts.

5. T. O.K. Lab. work exercise in the book . . .

6. Sts. (general chatter . . .).

The concern for consensuality is shown in the discourse not only by the teacher enumerating in #E-1 the 'factors' studied and discussed, but also ending it with a request for "any questions?" from the class, in #E3. Perhaps, the entire post-laboratory discussion may be regarded a session in pedagogic consensuality as it precedes the 'write-up' and submission of laboratory reports.

Summary. We see pedagogic tactics incorporating teachers' concerns for consensuality embodied in a variety of metacommunicative utterances.

For example:

B-86. T. So . . . aa . . . how do you feel about that?

B-92. T. O.K. any other questions?

B-100. T. O.K. . . . O.K. . . . aa . . . how are we feeling? Everybody happy?

C-36. T. Everyone O.K. up to there?

C-61. T. Is there any problem with this?

C-73. T. Does that help you?

D-1. T. O.K.?

D-3. T. Any question?

E-3. T. Any questions?

Such utterances inviting either questions, or comments or responses to specific questions, occur typically at the end of natural episodes within the discourse and are directed either to the whole class or to individual students. Depending upon students' verbal as well as 'silent responses' to these utterances, as 'heard' by the teacher, the teacher either prolongs the episode, or moves on to another discourse topic, i.e., begins a new episode.

As we have seen, through such utterances teachers attempt to seek a consensus with their student(s) regarding the concordance between teaching and learning. We have also seen that the direction of discourse subsequent to such utterances depends on student response to them--more importantly, to the responses as 'heard' by the teachers. We can infer that the concordance is sought as feedback for appropriate modification, if and as considered necessary, of the teaching/learning discourse: the modification is undertaken with a view to making it possible for the student(s) to learn the subject matter of the discourse.

In conclusion, then, the analysis yielded several examples of metapurposive metacommunicative utterances that embody the concern of teachers for pedagogic consensuality, with their students, of their teaching discourse. Incessant striving by a teacher for pedagogoc consensuality emerges as a major driving force for the continuation of a viable teaching process--when the latter is viewed as a distinct communicative process in an "unequal-power" classroom communicative system.

Consensibility Check

A necessary condition for pedagogic consensuality is that communication be consensible. To be brief about that, we recall Ziman's point that utterances are consensible to a listener if they are unambiguous and clear enough that the listener can give assent or dissent--in other words, if they 'make sense'.

In this section of the analysis, attention is focussed on pedagogic tactics which embody the concern of teachers for the consensibility of discourse. The reader is alerted to distinctions which will emerge among auditory consensibility, cognitive consensibility, and linguistic consensibility. Samples of discourse from the classrooms of Teachers I, II, and III are used again but, for the sake of argumentative flow, these appear now in a different order.

Teacher III. To begin with we consider an excerpt from a Chemistry 30 lesson. The students have been studying for several periods, through a pre-lab., lab., and post-lab. sequence, various factors that affect the rates of reactions. They are about to consider the question: "Why does each of these factors affect the rates of reactions in the way that it does?".

Excerpt F

1. T. We are looking at the factors that affect the rate of reactions, the experiment that you had performed. . . . Now again, we identified a set of major reaction factors or reaction rate factors and *let's just let's go, review quickly before we go on*. Name one of them.
2. St. Nature of compound.
3. T. *Nature of compound*.
4. T. *O.K.* *nature of reactants*. What do we mean by the nature of reactants?
5. St. Type of bonds.
6. T. *Craig*?
7. C. Type of bonds.
8. T. *O.K.* *it involves type of bonds* . . . anything else?
9. St. State.
10. T. *State*. What else? What else is involved in terms of nature?

First of all, we observe that the teacher has decided to find out what the students have learnt thus far, before attempting the new topic. He suggests in #F-1, "Let's just go, review quickly before we go on". On the surface it may appear, to use the sociolinguistic terms, that he is 'formulating' the topic of immediately-to-follow teaching/learning discourse. However, considering the wider context--including what has gone on before and what is to come--the discourse is seen as a pedagogic tactic embodying concern for consensuality. We can almost 'hear' the teacher saying: "I know what you have been studying and what you are about to study. I know the prerequisite understandings for the new topic. Let me ensure that you have this prerequisite before attempting the new topic, so that it may be possible for you to learn it." Such an inference is supported by the fact that this discourse, constituting a 'quick review one more time', comes after a detailed post-lab. discussion in the previous session.

However, our interest at this point lies in the teacher's concern for consensibility. We first see evidence of it in #F-3, in which the teacher simply repeats the preceding utterance by a student. We 'hear' this repetition as the teacher's attempt at ensuring that everyone in the class has heard the utterance #F-2, as well as letting the student who said it know about the words 'heard' and attributed to his utterance. This we shall consider an illustration of concern for auditory consensibility.

In #F-4 we note that the teacher first affirms the student's response, then reformulates it and follows the reformulation with a question. We observe a similar pattern again in #F-8. These say more than "I have heard you." Let us consider #F-4 and #F-8 evidence for the teacher's concern for cognitive consensibility. We note the teacher's partial acceptance of students' responses in #F-4 and #F-8 and also in #F-10, yet we also observe his persistence in eliciting from students that precise sense of the term 'nature of reactant' that he (the teacher) has. Regardless of rights and obligations of teachers and students in this connection (see Heyman, 1983, p. 30), and our appraisal of the teaching style from such a perspective, the evidence does demonstrate the teacher's concern for cognitive consensibility. In this case it is for the conceptual understanding of the term 'nature of reactant' in the context of chemical kinetics. This concern is further demonstrated in #F-18, #F-27, and #F-29, as the discourse proceeds:

Excerpt F (Continued)

11. St. aahm . . . Composition . . . Bonds in it . . .

12. T. O.K. What [what] do you mean by composition? . . .

13. St. aahm . . .

14. T. . . . or bond type . . .? Kirk?

15. K. How diluted or concentrated . . .

16. T. O.K. Does that come under the nature of reactants?

17. Sts. Shouldn't . . .

18. T. What do we include under the nature of reactants? Bond types . . .

19. St. State . . .

20. T. State . . .

21. St. aah . . .

22. St. How about the way the . . . aa . . . molecule is made up. Not necessarily the bonds . . . the shape of the atoms within molecules . . .

23. T. Shape of the atoms within molecules?

24. St. aa . . . tetrahedral or . . . aa . . . What else? . .

25. T. Did we study that?

26. Sts. (general laughter)

27. T. Did we study that as a factor? Just take a look at some of the things that we're analysing, O.K., as factors that we could identify at the level of study we're looking at. O.K. What were some of the things that we did look at in terms of nature of reactants?

28. Sts. (inaudible)

29. T. Looked at the ionic versus the bond type, but even before that [what] were we looking at in terms of the description with regards to the nature of reactants?

30. St. Bonds . . . The type of bonds . . .

31. T. O.K. . . . O.K. what was the first minilab. that we did in terms of identifying factors that affect the rate of reactions? What was the first minilab. that we did?

Here, in passing, we will note the occurrence of a teacher's concern for the commensurability of the discourse with the level of sense making activity. This is evident in #F-25 and #F-27.

Another pedagogic concern which is evident here, as an implicit problematic by its absence, is a prior establishment of a common frame of reference. We see in #F-31 a start being made by the teacher in making explicit the frame of reference from which, for example, the meaning of 'nature of reactant' is to be considered.

We shall return to these pedagogic concerns later on in the analysis. For the present, we return to the demonstration of teachers' concern for consensibility. The following is another excerpt from a post-laboratory discussion, immediately after a minilab. session in reaction kinetics in a Chemistry 30 lesson of the same Teacher III.

Excerpt G

1. T. To discuss the results of this lab., even though some of you may have not completely . . . (inaudible) . . . it up. All right if you look at procedures one, two, and three you are adding a sample of calcium to water, (writing on the board) calcium carbonate to water, and iron to another sample of water. What was the intent perhaps, what was the comparison, what was the measure (coughing) of comparison in those three?

2. Sts. ______________

(noise from the hallway)

3. T. . . . You take a look at the materials that you're reacting and what essentially is the basis that you're comparing on, in that set of reactions?

4. Sts. ______________

5. T. What is similar? What is different? What is the variation that is being shown in that series of reactions?

6. St. They are all . . . with water.

7. T. O.K. Everything is being added to water as a common component. Now how did the other, the second reaction, if you like, compare?

8. St. aa . . . They're metals . . .

9. T. O.K. We've got two metallic substances . . .

10. St. Two metallic, and then we've . . . combination . . .

11. T. . . . O.K. One is the form of (writing on the board) . . . (noise from the hallway) . . . calcium, the other, supposedly, a sample of iron and . . .?

12. St.

13. T. What about the third component?

14. St. It's got calcium . . .

15. T. O.K. It has calcium in it (writing on the board) . . . chemically we are representing it as . . . is compound . . . Now let's take a look at the direct result in terms of the observations (noise from the hallway continues) . . . How did the reactions compare with these components with the common . . . (inaudible) . . . water in terms of rate of reaction. How does the rate of reaction compare? Kirk?

In this episode we 'hear' the teacher "reformulating" his question (e.g., in #G-3 and #G-5) until he receives a response in #G-6; evidently the 'silent responses' from the class at #G-2 and #G-4 are 'heard' by the teacher as inconsensibility of his utterance. This inconsensibility is evident as linguistic and cognitive but not auditory. This is supported by the fact that the questions are reformulated and not merely repeated. In #G-7 the teacher reformulates the student's response indicating his consensibility with the student with regard to that particular response--that he (teacher) has heard it, agrees with it, and this is how he understands it. We see a similar evidence in #G-9 and again in #G-15. In #G-1, #G-11, and #G-15 we also note the teacher writing on the board, as also noted in earlier excerpts. For our purpose we shall not attach importance to this act, save to say that this is one of the ways teachers communicate while teaching in a classroom.

Teacher I. We now examine an excerpt from a Chemistry 10 lesson in a continuing unit on chemical nomenclature--specifically, recognizing chemical reactions and writing balanced chemical equations for the same.

Excerpt H

1. T. O.K. Students let's have a look at the Hydrocarbon combustion. And as . . . aa . . . what I started to say was . . . the . . . aahm . . . "A" students are always writing little notes, in their books. So, I would advise you to . . . aa . . . write some things in here . . . aahm . . . First of all, what is a hydrocarbon?

2. Sts. ________________

3. T. We said this before but better to write it down. What is it?

4. St. aahm . . . hydrogen with oxygen . . .

5. T. Just a minute. Just what is a hydrocarbon?

6. St. Oh. . .

7. St. Hydrogen . . . (inaudible) . . . St. What is it? St. What is it? hydrogen Scott . . . (chatter . .) a hydrogen and carbon . . . compound . . .

8. T. Renita?

9. R. aa . . . Just hydrogen and carbon . . .

10. T. O.K. It's a compound that contains only carbon and hydrogen. So what you have to do, is look for a compound that has only those two elements. Now you know you can see that the next example "b" is . . . aa . . . is $C_{25}H_{52}$. Don't get snowed by all those big numbers. Just look at the elements that are present. It's only carbon and hydrogen. Right?

11. Sts. Right.

12. T. There's thousands of hydrocarbons. It's different [the] ways of arranging the carbons and hydrogens and different amounts of carbon and hydrogen in the molecule. But they all have one thing in common and that's just that they have those two elements there. So that's why they . . . call . . . hydrocarbon . . . Combustion because it's always burning a hydrocarbon. Of course combusion I just said what it means What is it?

13. Sts. aahm . . . Burning . . .

14. T. Burning right? combustion refers to burning. This particular type of compound . . . aa . . . the most common use of it is for the energy stored in the bonds we [we] use it for energy . . .

Here in #H-3 the teacher repeats his advice, and his question. This is evidently a case of concern for auditory consensibility. This observation is supported by another repetition of the teacher's question in #H-5, apparently to rectify the inconsensibility reflected in a student response in #H-4. The evidence for the inconsensibility at #H-4 is supported by student utterance #H-6. A similar auditory consensibility concern is demonstrated by the sequence #H-12 - #H-14. But, #H-10 provides evidence for cognitive consensibility, as the teacher reformulates Renita's response into an acceptable definition of hydrocarbons.

In this excerpt as in excerpt F and indeed almost all lessons observed, we notice teachers employing a short question/answer sequence as a pedagogic strategy. Viewed from the perspectives of concern for consensibility, such a strategy incorporates a very powerful pedagogic technique through which a teacher communicates with the student(s) as to what he (teacher) wants the student(s) to know, what he (teacher) has heard and understood the student(s) as saying, and what he (teacher) would like the class as a whole to hear and understand.

Teacher II. This technique illustrating the teacher's concern for both auditory and cognitive consensibility is, once again, demonstrated in the following excerpt. This time, it is from a Chemistry 20 lesson in a continuing unit on chemical bonding.

Excerpt I

1. T. . . . aa . . . Turn it back to page D or G (inaudible), back to G3 and I just want to discuss as to . . . to . . . you . . . basically what is going to happen in this chapter. First of all what they are going to do, they are going to take two elements and put them together. When you put two elements together what do you form?

2. Sts. Compound. Compound. Compound.

3. T. What do you form, Troy?

4. T. Compound.

5. T. Compound. So what you are going to have is first you gonna talk about putting elements together forming compounds and talk about the kind of forces that hold different atoms together in a compound. And very basically we've gone over two types of forces. Does anyone remember the two types of bonds that hold . . . aa . . . different types of atoms together?

6. St. Covalent and ionic.

7. T. There is . . . one is called?

8. St. Covalent.

9. T. Covalent. What type of structure will that form if you get a covalent?

10. St. Sharing.

11. T. You get a sharing of electrons. What kind of structure occurs from it? . . . Does anyone remember? . . . Jim?

12. J. Molecule.

13. T. You get a molecule. So, Joanne you come up and be an atom for a minute (inaudible). Park on there. (students' laughter) O.K.?

14. J. O.K.

15. T. Two different types of atoms, and we are going to come together, and here is the electron (points at a meter stick). If we are ionic substance what would, what would happen to this electron?

16. St. One is charged. One is negative. One is positive.

17. T. What kind of things go together to form an ionic substance?

18. St. Metal . . .

19. T. Metal what?

20. Sts. (inaudible)

21. T. Jude?

22. J. Ions?

23. T. If you are going to have an ionic substance you are going to be putting two ions together and ions are . . . What did we describe ions are?

24. Sts. (inaudible)

25. T. Remember, I said atoms have net charge zero. What are ions?

26. Sts. Charged particles.

27. T. How do they become charged?

28. St. They lose or gain electrons.

29. T. They gain or lose electrons. So here is the electron. If I got one to give away, what kind of ion would I be? If I am going to give away a negative, I am going to become?

30. Sts. Positive.

31. T. Positive. If the other atom receives a negative that . . . atom will become?

32. Sts. Negative.

33. T. Negative. So now, we got two ions coming together to form what type of compound?

34. Sts. (inaudible)

35. T. Ions form what type of compound?

36. Sts. Ionic.

37. T. Ionic. So, now, we got an ionic substance. How do we share this electron? (Students' laughter) (teacher and Joanne holding the meter-stick together)

First, we hear teacher repeating his question in #I-3 and directing it to a particular student, despite the fact that other students had given the acceptable answer. We say 'acceptable answer' as the teacher himself repeats it in #I-5. Evidently, his concern for consensibility is with Troy at this point.

But then throughout this excerpt we see a pattern: (a) teacher questions, (b) student(s) respond(s), (c) teacher repeats question, (d) student(s) respond(s), and (e) teacher repeats response (e.g., #I-5 to #I-9, and #I-33 to #I-37; or more often simply a pattern of (a), (b), and (e), e.g., #I-9 to #I-11, #I-11 to #I-13, #I-27 to #I-29, and #I-29 to #I-31). On the surface these patterns appear cyclical. But the metaphor of a helix would be more apt. Thus, as the teacher leads his class through a pedagogic helical climb towards the "point" of the discourse he does so consensibly with his students. When consensibility becomes problematic, the 'climb' is modified; for example, we may see a pattern of (a), (b), (c), (d), and (e) instead of simply (a), (b), and (e). These patterns confirm the teachers' concern for the consensibility of the pedagogic utterances in the 'here-and-now' of the discourse.

Since such patterns occur in the pedagogic discourse of all three teachers and at all three grade levels, one can discount 'idiosincrasy-of-a-teacher' as an explanation for the occurrence of these patterns. But, by the same token, one must accept the peculiarity of these patterns in relation to the discourse type.

Summary. Thus, through excerpts F to I we see features of pedagogic discourse embodying variations of a tactic that reflects teacher concern for consensibility. We shall call such a pedagogic tactic Consensibility Check. These tactics are employed by teachers to ensure that the utterances in their pedagogic discourse are consensible - i.e., are heard and understood in just the acceptable ways by all concerned. We have seen evidence that a consensibility check can be auditory, linguistic, or cognitive, in a variety of utterances through which teachers do one or more of the following:

i. They repeat student(s)' or their own utterances.
ii. They reformulate student(s)' or their own utterances.
iii. They repeat and affirm student(s)' utterances.
iv. They affirm and reformulate student(s)' utterances.
v. They end their utterance(s) with a specific question either to a particular student or to the class as a whole.
vi. They engage in a sustained sequence of 'teacher questions-student(s) respond(s)-teacher repeats response(s)', as a pedagogic technique.

It must be emphasized that the above is not intended as a complete list. Such a list or categorization is not even contemplated in the 'contextual gestaltic' conception of meaning of an utterance as employed in the study. This enumeration is merely illustrative of some of the evident ways teachers employ the metapurposive pedagogic tactics of consensibility check, in their attempts to establish consensibility between themselves and their students. And, we remind ourselves, as stated earlier, that pedagogic consensibility is to be recognized as a prerequisite to pedagogic consensuality in the classroom teaching/learning communicative system.

Commonality of Frame of Reference: Frame Check

It has been suggested earlier that consensibility is a prerequisite to consensuality. There appears to be another precondition that we have seen become evident in a discourse, but by its absence (e.g., excerpt F, utterances 1 through to 31, pp. 92-95). The absence of this precondition is noted both by the participants and by us, as observers, as a problematic aspect of communication. Thus far, we have been attempting to capture the salience of pedagogic concerns--consensuality and consensibility--directly from the smooth flow of pedagogic discourse. Now, it is through the recognition of this problematic by the teacher and his attempts to remedy the situation that we will elucidate the third set of pedagogic tactics of interest to us. As Stubbs also suggests:

> By looking at what happens when people fail to get the message across, as why this happens and what speakers do in order to reinstate the normal smooth flow of interaction, one can gain insight into the routine structures of behaviours. (Stubbs, 1976, p. 157)

For this purpose, we will examine two selections from the teaching discourse of Teacher I and Teacher III, respectively.

Teacher I. We first look at an excerpt from a Chemistry 10 lesson in a continuing unit on chemical nomenclature.

Excerpt J

1. T. Now here is the picture. Remember when you want to put sodium with sulphate and we are now writing a new compound are we not?

2. M. Uhun . . .

3. T. Howard, whenever we write a new compound what do we always think about first? What is the information we need when we are trying to write a compound by putting a positive with a negative?

4. H. (inaudible)

5. T. Yes. What do we have to know though? Information? Robin?

6. R. Positive will go with negative . . .

7. T. Well . . . aahm . . . I'm thinking of writing. She's told us what we are going to put together, and I'm thinking of what information you have to have to know how to put these together? Steve?

8. S. Valences.

9. T. Valences is what I had in mind. Does that recall anything Howard?

10. H. Yes.

11. T. So we can . . . that's how we always do it when we are writing a new compound. Anytime we want to write a compound we think of valence. O.K. So, what are the valences of . . .?

We first note, through teacher utterance #J-7, that the teacher recognizes that the discourse thus far, i.e., from #J-1 to #J-6, has come to a problematic impasse. We say this because the teacher gives a noncommittal reaction to Robin's response in #J-6--"Well . . . aahm . . .". We note Robin's response is part of the teacher utterance #J-3. It is to the credit of the teacher that he recognizes within a short episode of only six utterance interchanges that he and his students are not thinking along the same lines vis-a-vis the questions under consideration. In other words, they have different frames of reference. The students evidently (#J-6) are thinking from the point of view of what (which entities) must be put together. The teacher, on the other hand, is thinking from the point of view of how (valence) to put together whatever has to be put together. Next, we 'hear' the teacher's attempt to repair this breach between him and his students in #J-7. He makes this explicit through his utterance #J-9. And, in #J-11 we 'hear' him--apparently satisfied with accomplishment of the task of restoring the commonality of frame of reference--as he continues with his teaching discourse.

Teacher III. The next excerpt that we shall consider is from a Chemistry 30 post-laboratory discussion in the continuing unit on reaction kinetics.

Excerpt K

1. T. . . . Now Joanne has identified by looking ahead perhaps, some of the information. But what we're talking about here is homogeneous versus heterogeneous reactions in terms of phase of materials specifically the reactants presents. Now (writing on the board) . . . O.K. So, we're talking about a homogeneous

reaction with regards to reactants and we say that they must be in the same phase to qualify as homogeneous. To be heterogeneous reaction, looking with respect to reactants there is a different phase of those reactants. Now we also have to take a good look at what we mean by phase of reaction. What does phase of reaction mean to you?

2. St. Solid, liquid, . . .

3. T. Solid, liquids, gases . . .? (writing on the board) . . . What is another term that we've sometimes applied to solids, liquids, gases other than phase?

4. Sts. State . . . State . . .

5. T. State of matter . . . O.K.? Now, what I want you to do, that take a good look at it in terms of this terminology (pointing at the board-work) . . . being applied to state of matter in terms of what we mean here by the same or different phase with regards to defining reactions, as homogeneous or heterogeneous with respect to chemical reactants in each reaction . . .

(He then goes on to demonstrate three different reactions with running commentary.)

6. T. . . . And we do take care here (writing on the board) . . . in identifying the difference here in terms of what we mean by [by] phase as compared to state because we can have two similar phases in contact with each other two solids two liquids that do not mix where there is only a layer or a surface contact between the two it still be heterogeneous. Whereas you get two similar states completely intermixed if you like high exposed surface area. . . (inaudible) . . . two particles then you have a true single phase homogeneous reaction. Any question?

7. Sts.

8. T. O.K. the last factor that we'll consider . . .

To begin with, we notice the teacher's concern with commonality of frame of reference at the beginning of the episode. This is usually the juncture at which teachers attempt to establish a common frame of reference in order to avoid later problems in communication--problems of talking at cross-purposes, so to speak. Then, we recognize his concern in this regard in #K-3 where he senses students using 'phase' in the sense of aggregation of matter, through their response in #K-2. He seeks confirmation of this in #K-3 and receives it in #K-4. And now in #K-5 we 'hear' him recognize the problematic of "frame clash" as he points out to the students the context in which the term 'phase' is being used. He then goes on to demonstrate, practically, his frame of reference which apparently is to do with the intermixing of reactants rather than the aggregates of matter, as he later makes it explicit in #K-6.

Here, we are not concerned with whether or not the teacher has been successful in establishing commonality of frame of reference, or for that matter even in clarifying his own frame of reference vis-a-vis the term 'phase' within the context of homogeneous and heterogeneous reaction systems. Our interest is with the demonstration of a concern for the same on the part of the teacher. The evidence for his concern is further supported by his attempt to seek consensuality with the class in this regard. We 'hear' this as "Any Question?" in #K-6, before the teacher moves on to another discourse topic in #K-8.

Summary. Evidence for teacher concern for commonality of frame of reference has been found in instances where commonality was missing. We have seen illustrations of pedagogic tactics that teachers employ as they attempt to establish or restore commonality of frame of reference. Let us refer to any such tactic as a Frame Check.

The explicit indication that a Frame Check is being used can usually be detected towards the end of those episodes where considerable pedagogic dissensus occurs. The interchanges in such episodes usually end up in such metacommunicative utterances by the teacher as "This is what I had in mind," or "This is what I was thinking of," or "This is what I want you to think of," or "This is how I want you to think about . . . ," etc. Sometimes, as illustrated in excerpt K, teachers' attempts at ensuring commonality of frame of reference are indicated through teaching utterances, stating what he (teacher) had, all along, in his mind.

It may well be said, that the best way to ensure commonality of frame of reference is at the start of an episode where a teacher may begin by saying: "This is what I want you to think of" and "This is how I want you to think about" the topic under consideration. But in the immensely intricate process of an ongoing discourse, one wonders if one can establish, once and for all, a common frame of reference for an episode let alone an entire discourse. Probably not. Hence it is not surprising to find a continuing preoccupation in pedagogic discourse for commonality of frame of reference, as well as for consensibility and consensuality.

Commensurability Check

Apart from teachers' concern for commonality of frame of reference, consensibility of utterances, and consensuality of the discourse, we have seen evidence of at least one more pedagogic concern that is of interest to us for the present study (for example, Excerpt B utterance #3, p. 69, and Excerpt F utterance #25, p. 94, and utterance #27, p. 95). We find it interesting from the perspective of the quandary that originated this study--the dilemma of reconciling the integrity of students as learners with the integrity of subject matter as dictated by course requirements, curricular structure, and nature of the discipline. Whereas concern for consensibility reflects a respect for the integrity of learners, respect for the integrity of the subject matter is reflected in what we shall call, here, a concern for commensurability. Concern for commensurability may be in respect of the course content, curricular structure, curricular emphasis, nature of knowledge. Or, it may simply be to do with the abstraction-level of sense-making activity that a class is engaged in.

As in the case of the other three pedagogic concerns, discourse is used to illustrate, through various utterances, teachers' pedagogic tactics to ensure the commensurability of their discourse. Let us call any such tactic a Commensurability Check. In this case, the order in which the three teachers' discourse is examined is Teacher I, Teacher III, and then Teacher II for the sake of the flow of the argument.

Teacher I. This material comes from a continuing lesson on chemical nomenclature in a chemistry 10 class. The students have just finished the unit on writing chemical formulae, and are engaged in a post-assignment discussion on the same topic:

Excerpt L

1. St. They are talking about S and then it has a bond then there is the C and then a bond and then S. Why wouldn't they have the two bonds so they were at angles?

2. St.$_2$ Like they were in water molecule.

3. St. Like, you say we weren't supposed to draw shape.

4. T. O.K. Yea. That's, that's not for everything though . . .
(Teacher goes on to explain why they should show bent shape in one case and not in the other, and after a lengthy explanation:) . . .

5. T. . . . aa . . . If I was going to explain this fully with, I have to . . . into a lot more detail than we do in Chem. 10 because it has to do with sp^3 hybrid orbitals and bonding orbitals.

6. St. What about H_2O then? Why is it that way?

7. T. Well H_2O . . . Remember the oxygen and that . . . the same with sulphur by the way, has two unshared pairs or lone pairs like that, then it has two singles and so the bond is here and here (pointing at the board-work) . . . You know what I need to do just . . . give me a second . . . Here it's better to show this with models . . . (Again, the teacher goes on to explain in a rather lengthy monologue . . .) . . . and we don't go into that at our level.

8. St. So you can't make that?

9. T. I can't show it with this (pointing at the ball-and-stick models set). I have to . . . We have to go into quite a bit of advanced theory . . . and as we move along to get more experience and learn more about bonding we, we'll get better at drawing shapes . . .
(In the face of some persistent questioning by a few students the teacher then continues:)

10. T. . . . ahm . . . This is a kind of a cop-out but you know these answers were copied out of the Alchem* key and they don't expect you to know about double bonds and . . . aa . . . so that isn't. This is an oversimplified answer. Your observation is very exact. In order for me to [to] explain it all, I'll have to . . . some careful thinking about it and again it's beyond the scope of what you need to know . . .

11. J. So . . .

12. T. . . . for Chem 10.

(And further in the same discourse after the investigator was also involved, at the invitation of the teacher . . .)

13. J. So, should we do that (referring to the diagram on the board).

14. T. No way!

15. I. Not . . . Not at this stage, eh!

16. T. Beyond the scope of our course to worry about that . . . (and further . . .) So you can see that it's a . . . You can see what the problem is and . . . aa . . . So the Alchem just chose to simplify it for you and say you don't have to know exactly how many bonds are there between some of these more complicated structures . . . And, we don't need to get bogged down with these bonds. Yes?

17. J. O.K. . . .

18. T. . . . No. No. No. absolutely not. You are not required to know about double bonds and triple bonds . . .

This excerpt clearly demonstrates the concern that teachers have to keep their teaching utterances and the level of their discourse commensurate with course content. For instance, we 'hear' the teacher in

---

* "Alchem" refers to a set of chemistry teaching materials.

#L-10 and #L-16 showing concern for the commensurability of discourse with the program of studies being followed (Alchem 10 in this case). And again, in #L-5, #L-7, #L-9, #L-10, #L-12, #L-16, and #L-18, the teacher very explicitly expresses his hesitation in going beyond the level and scope of the course. This unwillingness is illustrative of the teacher's concern for commensurability of the discourse with the structure of the curriculum.

This is not, however, to suggest that teachers don't entertain students' ideas that appear to be beyond the level and scope of the course. In this particular instance the teacher in fact spent considerable time and effort to satisfy Jason's relevant concerns and curiosity. But all through this effort he continued to insist on keeping the level of discourse commensurate with the level and scope of the course of studies.

Teacher III. Next we look at the continuation of the Chemistry 30 lesson begun in Excerpt F. The beginning of the lesson (pp. 92, 94, and 95), was noted as a quick review one more time (p. 92). Here the lesson continues.

Excerpt F (Continued from p. 95)

32. Sts.
33. T. What combinations?
34. St. aaa . . . The . .
35. T. Karen?
36. K. The first minilab?

37. T. The very first minilab . . .

38. K. . . . Water . . . (inaudible) . . .

39. T. No no no. That was, that was . . . in terms of identifying the rates before we use . . . rate . . .

40. K. Oh, Oh. I realize that . . .

41. Sts. (inaudible) . . .

42. T. Very first minilab we did under . . . (inaudible) . . . rate of reactions?

43. St. Rate versus reaction . . .

44. T. Rate versus reaction. What [what] were you doing there? What combination did we use in that study?

45. St. Nail . . .

46. T. O.K. Used a nail, pieces of calcium versus . . .

47. Sts. Marble . . . marble . . . marble chips . . .

48. T. . . . and calcium carbonate. What did we identify there in terms of what differences there were? What did we incorporate in the general heading: nature?

49. St.

50. T. Was there difference in the reactants there? What was the difference in the nature of reactants?

51. St. . . . aa . . . Some of them would become soluble in water, other ones wouldn't mix in with water.

52. T. O.K. Some of them were soluble or not soluble . . . All we want to know is what do we mean by this term nature of reactants . . . (interruption)

53. T. Nature of reactants . . .
(noise . . .)

54. T. . . . is a factor which will affect the rate of reaction. Then, what do we mean by the nature of reactant?

55. Sts.

56. T. What were we studying . . .? What were we looking at specifically when we picked the nail, and we picked the calcium, and we picked the calcium carbonate . . . What were the differences there that we then incorporated under this broad category?

57. St. . . . aahm . . . Just the way they act . . . they reacted . . . with other

58. St. (inaudible)

59. T. Right there WAS a difference in the rate at which they reacted but why? . . . What was the difference with regards to the reactants themselves . . . What was different about them?

60. Sts.

61. T. Were they all the same reactants?

62. Sts. No . . . (inaudible) . . . structure . . .

63. T. Were they all the same reactants?

64. Sts. No . . . no . . . no . . .

65. T. No. What was different about them? What was different about the nature of those reactants?

66. Sts. ahnhe . . . (inaudible) . . . element . . .

67. T. Different element. O.K. We had iron, we had calcium. What about the marble chips?

68. Sts. (inaudible) . . . calcium . . . (inaudible)

69. T. Was it a metal . . . Was it an element?

70. Sts. No . . .

71. T. No. Was it compound?

72. Sts. Yes.

73. T. So what is nature used, for instance for very general things? Like are they metals, are they non-metals, are they compounds, or are they molecular or ionic compounds? (knocking at the door) . . . (inaudible) . . . as well as they incorporate bond type. So . . . (inaudible) . . . essentially to summarize in terms of what IS the reactant, it will make a difference to the rate of reactions as to whether it is metallic calcium or metallic iron in combination with a common . . . (inaudible) . . . O.K. Second factor then?

All through this excerpt we 'hear' teacher trying to keep the level of abstraction of the discourse the same as the level of sense-making activity that the class had been engaged in thus far. This 'level' concerns the very first minlab in the series, the observations therein, and the consensus reached on the basis of the post-lab discussion, which was kept to the substance type and bond type only. This observation is supported by #F-73 which comes after a rather long and laborious look back into the relevant minilab activity.

Teacher II. For our last excerpt we go back to a previously reported quoted excerpt--C, from a Chemistry 20 lesson. Teacher utterances #C-2 and #C-16 are repeated below (partially). They must, of course, be viewed within the context of the excerpt of which they form a part (pp. 80-83).

#C-2 (pp. 80)

T. O.K. Chapter Two. Is there a problem there (students still talking amongst themselves . .) Yes? No? O.K. . . . aa . . . Last day I asked you to start the reading G1 and G2. Very quickly, what I would like to do is to go over G1 and G2, then we'll mark the little chart and then we are gonna see how else we use this tool the new tool that we are using is called the Lewis dot diagram and just as a review I like to go over and talk about say chlorine the electron energy level representation for an atom of chlorine . . . (indistinct). What is the (indistinct) required for that?

#C-16 (p. 81)

T. O.K. This is the electron energy level representation. This is the old way of representing atoms (pointing to his 'board-work'). There is another way to represent atoms and it's called (writing on the board) Lewis . . . So now we are going to learn a new scheme or a new way to represent atoms and eventually use those to represent molecules also and with the little change . . . ahm . . . finally get to the . . . aa . . . diagram which is called structural diagram . . .

In these two utterances the teacher gives explicit metacommunicative directions about the logical status of 'energy level diagram' and 'Lewis dot diagram'. These are to be understood as tools, representations, or ways of representing atoms and molecules. Such explicit utterances demonstrate teacher concern for the commensurability of discourse with the nature of knowledge.

In this excerpt, however, we do not hear the teacher making any comments explicitly or implicitly, as to the logical status of electrons, protons, atoms, molecules, energy levels, etc. It may well be that these terms were introduced much earlier in junior grades, and the teacher is assuming that the students make the logical switch by themselves on the basis of their earlier experiences in the study of science. Whether this actually obtains, however, was not a matter of interest for this study.

Summary. The discourse shows evidence of teacher concern for commensurability through various pedagogic tactics, as these are embodied in diverse metacommunicative utterances. Commensurability Checks are manifest in such tactics as attempts to keep the discourse at a particular level of sense-making activity, or within the scope of course requirements, or consistent with the nature of knowledge (by, e.g., indicating the logical status of the entities being talked about).

Conclusions from The Analysis

The major objective for the analysis, as set forth at the beginning of this chapter, was to demonstrate the occurrence of pedagogic tactics reflecting teacher concern for four aspects of discourse in chemistry classrooms. This the analysis has done. The pedagogic tactics have been dubbed Consensuality Check, Consensibility Check, Frame Check, and Commensurability Check. Their form and function have been elucidated through a variety of teacher utterances within the context of relevant pedagogic episodes and discourse.

The first of three subsidiary purposes, implied for the analysis, was to bring out the salience of the conceptions of pedagogic consensuality, consensibility, commonality of frame of reference, and commensurability in classroom teaching/learning discourse. The prominence of these conceptions in pedagogic discourse has been demonstrated throughout the analysis in two ways. First, these have been inferred as teacher concerns underlying the aforementioned pedagogic tactics. Secondly, these have been linked to the 'upshot' for the learner--that it may become possible to learn. Thus, as teacher concerns, these conceptions form a vital link in an analytic chain from utterance to tactics to concerns to upshot. For example, if a teacher asks: "Any questions?", and we interpret it as a consensuality check, we are suggesting that the underlying teacher concern for this utterance is to seek consensus for the concordance of teaching and learning. And, we are also suggesting that the purpose behind this concern is to ensure that it is possible for the learner to learn. We would, indeed, be hard pressed to complete this chain--from observed utterance to inferred upshot--without the preeminent conception of pedagogic consensuality.

The second subsidiary purpose implied for the analysis was to emphasize the importance of these conceptions in understanding the difficulty of the subject matter of a teaching/learning discourse. This has been achieved, in the analysis, through the linkage between these conceptions and the upshot for the learner.

For example, if a particular discourse-topic is perceived to be difficult by students, it could be that a prior consensus as to the concordance between teaching and learning of the prerequisite topic had not been ensured. Alternatively, it could be that the teaching utterances have not been made consensible during the discourse. Or, if it had been difficult to reach a consensus with the students in a discourse, it could be that the teacher and students have had different frames of reference. Again, if the students find a given discourse too easy and hence boring due to 'deja-vu', it could be that the discourse is below the level of the course. And, on the other hand, if the students find the subject matter too difficult, it could be that it is above their comprehension capability, and as such is regarded beyond the scope of their course. Similarly, if the students appear confused in their employment of the terminology and the concepts of a discipline, it could be that the logical status of various terms and concepts employed during teaching/learning discourse had not been clarified in accordance with an explicitly stated view of the nature of knowledge involved.

The third implied subsidiary purpose for the analysis was to demonstrate the power of a fresh way of looking into pedagogic problematics, both as a way to seek appropriate remedies and a means to gain further insight into the phenomena of teaching. This the analysis has illustrated for a specific pedagogic problematic and a particular approach in the study.

The problem of concern is the perception among students that chemistry is an unusually difficult subject to learn. The fresh approach is to regard teaching as a unique communicative process, and to view this process through the conceptual lenses first employed by John Ziman in his communal knowledge model for science. Another significant element in the approach is to explore naturally occurring chemistry teaching for the metacommunicative teacher utterances within the contextual gestalt of the discourse. These theoretical and methodological orientations are coupled with our intuitive understanding of the discourse type in the approach employed in the study.

The analysis has shown that this approach points to extremely important and different aspects of teaching, as a possible remedy for the problem of 'difficulty' of chemistry for the students. These aspects have not been considered so far by researchers for understanding the difficulty of a teaching discourse or its subject matter. More importantly, the approach employed in the study has enabled us to recognize some vital elements of the phenomenon of teaching itself. For example, teacher's incessant strivings for consensuality with its prerequisites--consensibility and commonality-of-frame-of-reference--and their concern for commensurability of their discourse emerge as major driving forces to guide and sustain a viable teaching process.

Thus, the importance and usefulness of the four conceptions, as lenses through which to view a pedagogic problem, have been demonstrated. In addition, the analysis demonstrates the power of the notion of a contextual gestalt in ascribing meaning to an utterance within a discourse. Without such a notion our inferences could be dismissed as mere intuitions. Our contention that metapurposive pedagogic tactics are embodied in various teacher utterances rests on an analysis that ascribes meaning to those utterances within the context of an episode of discourse. Thus the concept of contextual gestalt provides empirical credibility to our interpretation and lends confidence to our inferences.

It is important to clarify the logical status of the notions of utterance, tactics, and concern as employed in this analysis. The utterances are of the empirical realm. Within a given pedagogic context we ascribe them certain meanings and interpret them as pedagogic tactics of one sort or the other, reflecting particular pedagogic concerns. It must be emphasized, however, that our interpretations (for pedagogic tactics) and our inferences (for pedagogic concerns) are of the pedagogic utterances within the context of pedagogic discourse; and the latter are empirically existent.

A final methodological consideration must now be made explicit. For the sake of clarity of exposition and analytic convenience, the four tactics have been examined one at a time. We wish to emphasize, nevertheless, that more than one of these tactics may be 'seen' to operate within a given episode of the discourse. In our analysis of some excerpts we have noted explicitly the occurrence of some of the nontargeted of these tactics. And we imply such cooccurrence when we suggest that in the ongoing process of a viable classroom teaching discourse, teachers are incessantly preoccupied with such pedagogic tactics.

CHAPTER FIVE

Conclusion

In bringing the study to a close, this chapter serves a threefold purpose. First, some of the more salient features of the study are summed up. Second, the findings are summarized and their nature is discussed. Finally, some implications of these findings for pedagogic practice, teacher education, and further research are suggested.

Some Salient Features

A Fruitful Area for Research

This study had its origins in the recognition that otherwise intellectually able students find the study of chemistry a difficult endeavour. An examination of relevant research, particularly on classroom teaching/learning interactions, led this investigator to a realization that one of the fruitful areas of research into the reasons for the difficult reputation of chemistry might be the very manner in which teachers communicate with their students, as they go about teaching chemistry in their classrooms. A further review of related research provided rather scant evidence of research studies of senior high school chemistry teaching discourse as it occurs.

In the past, considerable research effort nas been expended in describing and categorizing classroom interactions in different subject areas and at various grade levels. But, what pedagogic metapurpose(s) is/are served by given teacher utterances within the context of a pedagogic discourse? This question, unasked more often than not in previous studies, has redirected attention in the present study to teacher utterances in classroom teaching/learning discourse.

Of particular interest have been those utterances that reflect a teacher's concern for the conceptual clarity of teaching discourse--more specifically, those utterances through which chemistry teachers attempt to monitor the consensuality of their ongoing discourse.

Three features of the theoretical orientation of the study bear repeating here. First of all, teaching is regarded as a distinct communicative process with a specific metapurpose, within a classroom teaching/learning communicative system. The metapurpose is recognized as an 'upshot' for the learner--as making it possible for the learner to learn what is being taught. Second is the recognition that classroom discourse is an "unequal-power" interaction in which the onus to initiate, guide, sustain, and conclude the discourse rests with the teacher. And, the third, is the realization that the function of 'monitoring' utterances by teachers in the classroom is a 'feedback' function for modification of teaching.

Methodological Comments

The methodological commitment in this study has been to a 'contextual gestaltic' notion of the meaning of utterances, and to a naturalistic study of pedagogic discourse. It is worth noting that one first proceeds counterinductively, employing the initial theoretic orientations based on intuitive understandings of classroom events. This initial step provided the features of interest for the study. Then, at the data analysis stage, an inductive approach was employed to elucidate the form and function of these features. The analytic concern in this study has been with the demonstration of the occurrences of the 'target' features within and through the discourse itself.

Discussion of Findings

The Findings

The metapurposive pedagogic tactics. Four sets of metapurposive pedagogic tactics were identified in chemistry classroom teaching discourse. These were shown to manifest themselves in a variety of teacher utterances as the latter are interpreted within the perspective of the contextual gestalt of a discourse. The tactics were labelled as the Consensuality Check, the Consensibility Check, the Frame Check, and the Commensurability Check.

The pedagogic constructs. The 'checks' just mentioned have been inferred to serve the purpose of modification of the teaching process, and to reflect, respectively, the metapurposive teacher concerns enumerated below.

1. Consensuality between teacher and students for the concordance of teaching and learning.
2. Consensibility of teaching utterances for the students.
3. Commonality of frame of reference between teacher and students regarding the teaching/learning discourse topic.

4. Commensurability of the subject matter of the pedagogic discourse with the level of sense-making activity, the level and scope of course, curriculum, and the nature of knowledge involved.

The notions of pedagogic consensuality, consensibility, commonality of frame of reference, and commensurability have emerged in this study as significant and important pedagogic constructs with which to view the pedagogic problematic of the 'difficulty' of a pedagogic discourse or its subject matter.

Nature of Findings

It must be emphasized, however, that the significance and the importance of these constructs cannot be viewed in isolation from the methodology that allowed them to emerge. Also, the emergence of these constructs must not be seen as the so called objective orientation of teachers in their classroom discourse. Devoid of the context of discourse, an utterance by a teacher cannot be inferred to embody certain pedagogic tactics, or to reflect a particular pedagogic concern, or serve a specific pedagogic metapurpose. For example, when a teacher repeats a student's response, it may be that the teacher wants to ensure that the entire class has heard the response (the concern would be for auditory consensibility). Alternatively, the teacher might want the responding student to know what he (the teacher) has heard and understood (this concern would be for auditory and cognitive consensibility). Or, it could simply be a matter of habit on the part of the teacher. Only the context of the discourse will tell.

Thus, the underlying mechanism that generates a particular teaching behaviour (e.g., repeating a student response) may be either very simple or very complex, and can only be elucidated through the manifest interaction. The pedagogic constructs of consensuality, consensibility, commonality of frame of reference, and commensurability may be regarded as important elements in the underlying mechanism generating those metapurposive pedagogic behaviours that reflect a concern for the 'upshot' for the learner--as recognized in this study.

Justification of Findings

Empirical substantiation. This investigator recognizes the extreme intricacy of the phenomenon of teaching/learning as a communicative system. One is particularly aware of the constraints on one's findings due to limited sample of the phenomenon examined, and the investigative paradigm employed. It may well be that through a different paradigmatic lens these findings may not appear to be exactly the same; it is even quite likely that they may not even be revealed at all. But, then one must also recognize the incommensurability of such competing paradigms (cf. Butterworth, 1978, p. 322). While one may recognize the legitimacy of alternative investigative strategies and their respective findings, one must at the same time posit the justification of those findings in their relationship with empirical facts. From this point of view the pedagogic constructs of consensuality, consensibility, commonality of frame of reference, and commensurability receive substantial support from the phenomenon, as has been shown in this study.

Interactive investigative process. It has been suggested earlier that these pedagogic constructs have emerged inferentially through the phenomenon. It would be appropriate at this point to comment on the process involved, if only to clarify further the nature of the findings of this study. The investigative strategy has been to approach the phenomenon with some initial theoretic orientation and then let the phenomenon itself elucidate the findings. The investigative process has emerged in the present study as an interactive process--a process of interaction between the theoretical orientations on the one hand, and the phenomenon on the other.

A theoretical investigative orientation is not a rigid theoretical position, embedded in an established paradigm for the investigation of a phenomenon. Instead, it is considered more like a rather misty lens, which gets cleared by the light that shines through it from the very phenomenon one seeks to investigate with it. Just as the phenomenon, by virtue of being what it is, illuminates the theoretical constructs through clarification of investigative orientations, so too, the latter in turn enable one to find, locate or discover the very same constructs in the phenomenon. Thus, in a reflexive manner, one not only attempts to bring into sharp focus the elements of interest in the phenomenon, but also refines the very tools that enable one to locate those elements.

Findings of such an interactive investigative process can neither be classed as truly deductive nor truly inductive. Inferences drawn in such a manner are illustrative of what has variously been termed as 'reductive', 'abductive', or 'retroductive' inference. As Hanson illustrates,

> The critical moment comes when the physicist perceives that one might reason about data in such and such a way. One might explain this welter of phenomena P, throw it all into an intelligible pattern, by supposing H to obtain. But P controls H, and not vice versa. The reasoning is from data to hypothesis and theory and not the reverse. (Hanson, 1972, p. 88)

Implications of the Findings

Teaching and the Problem of 'Difficulty'

The notions of pedagogic consensuality, consensibility, commonality of frame of reference, and commensurability have emerged as significant and important pedagogic constructs in this study. The investigator would put forward that the keenest sense of significance and importance of these pedagogic constructs can be seen only in context: it concerns individual teachers' attempts at reducing the perceived difficulty of their classroom teaching/learning discourse.

For example, if an individual chemistry teacher discovers that students find his/her teaching difficult, (s)he might wish to examine the data of his/her classroom discourse from the perspectives of these pedagogic constructs and then attempt to take appropriate measures to alter features of the discourse. It must be emphasized that the 'appropriate measures' are not suggestive of a reduction in the rigour of the curricular requirements. Rather, they refer to the employment of suitable metapurposive pedagogic tactics, and the necessary modification of the teaching process in such a way that the difficulty is reduced for the learner, yet the learning is at the same level of rigour. Such an examination of a classroom discourse can be undertaken either by the teacher or by a consultant.

A New Focus for Teacher Education

Similarly, during teacher training student teachers could be taught these constructs as important and useful pedagogic tactics in their teaching repertoire. This can be done, initially, by examining classroom teaching/learning discourse of appropriate grade level and subject area, from the perspectives of these 'constructs', in cognizance of the 'upshot' for the learner as illustrated by the discourse. Then, during "practicum" the student teachers with assistance from their practicum supervisors could examine their own classroom teaching from these same perspectives. It is the contention of this investigator that such a teacher training strategy would prove beneficial to a novice teacher.

Some Questions for Research

Of course, it is only an intuitive contention for the present. Perhaps this can be an interesting problem for research in teacher education. An important and useful research program would be to analyze classroom discourse vertically, through various grade levels in a given subject area, from the perspectives of the pedagogic constructs identified in this study. Such a study could reveal the degree of need for incorporating the metapurposive pedagogic tactics in one's teaching discourse in relation to the grade level taught.

A similar study across various subject areas at a given grade level should further reveal the nature and dimensions of these constructs. For example, how does the nature of pedagogic consensus in a chemistry classroom differ from that in a language arts or a social science classroom? Or, for that matter, what is the nature of a pedagogic consentaneous agreement itself? One could explore these questions in terms of various elements in an "argument pattern" (cf. Toulmin, 1969). An extension of the present study could be a further exploration of chemistry classroom teaching/learning discourse from the perspective of its commensurability with the logical status of various chemical 'entities', and for evidence of "logical asides" (cf. Toulmin, 1952, p. 15), along with the logical level of the language of the discourse. This is suggested since these elements of pedagogic discourse in chemistry classrooms were not, systematically, explored in the present study. From the point of view of the commensurability of the discourse with the nature of knowledge involved such an investigation is indeed very important.

REFERENCES

Aschner, M. J., et al. A system for Classifying Thought Processes in the Context of Classroom Verbal Interaction. Urbana: Illinois, 1965.

Balzer, A., et al. A Review of Research on Teacher Behaviour Relating to Science Education. Association for the Education of Teachers in Science; ERIC Information Analysis Center for Science, Mathematics, and Environmental Education, Columbus, Ohio, December, 1973, ED 087638.

Bellack, Arno A. Contrasting Approaches to Research on Teaching. In B. Robert Tabachnick, Thomas S. Popkewitz, and Beatrice Beach Szekely (Eds.), Studying Teaching and Learning. New York: Praeger Publishers, 1981, pp. 59-75.

Bellack, Arno A., et al. The Language of the Classroom. New York: Teachers College Press, 1966, pp. 84-85.

Ben-zvi, Ruth; Hoffstein, Avi; and Samuel, David. "Modes of Instruction in High School Chemistry." Journal of Research in Science Teaching, Vol. 14, No. 5 (1979), pp. 433-9.

Berliner, David C. "A Status Report on the Study of Teacher Effectiveness." Journal of Research in Science Teaching, Vol. 13, No. 4 (1976), pp. 369-82.

Bojczuk, M. "Topic Difficulties in O-and A-level Chemistry." School Science Review, Vol. 63, No. 224 (March, 1982), pp. 545-51.

Bottomley, Jennifer M., and Ormerod, M. B. "Why do Children Choose Chemistry." Education in Chemistry, Vol. 19, No. 2 (March, 1982), pp. 42-43.

Brown, W. R. "The Effect of Process-Skill Instruction on Performance of Preservice Elementary Teachers." Journal of Research in Science Teaching, Vol. 14, No. 1 (1977), pp. 83-87.

Butterworth, Brian. "Maxims for Studying Conversations." Semiotica 24, 3/4 (1978), pp. 317-339.

Cavin, Claudia S.; Cavin, C. D.; and Lagowski, J. J. "The Effect of Computer Assisted Instruction on the Attitude of College Students towards Computers and Chemistry." Journal of Research in Science Teaching, Vol. 18, No. 4 (1981), pp. 329-33.

Cervellati, Rinaldo; Ferri, Roberto; and Perugini, Daniela. "Teaching Nuffield in Italy." Education in Chemistry, Vol. 18, No. 3 (May, 1981), pp. 71-73.

Chisholm, M. G. "Student Evaluation: The Red Herring of the Decade." Journal of Chemical Education, Vol. 54, No. 1 (1977), pp. 22-23.

Clark, Christopher. "A New Question for Research on Teaching." Educational Research Quarterly, Vol. 3, No. 4 (Winter, 1978-79), pp. 53-58.

Comber, L. C., and Keeves, J. P. Science Education in Nineteen Countries. Stockholm, International Association for the Evaluation of Educational Achievement, 1973, p. 135.

Corsaro, William A. "The Clarification request as a feature of adult interactive styles with young children." Lang. Soc., 6 (1978), pp. 183-207.

Deboer, George E. "Can Repeated Testing of Enroute Objectives Improve End of Course Achievement in High School Chemistry." Science Education, Vol. 64, No. 2 (1980), pp. 141-8.

Earl, R. D., and Winkeljohn, D. R. "Attitude of Elementary Teachers Toward Science and Science Teaching." Science Education, Vol. 61, No. 1 (1977), pp. 41-45.

Easley, Jr., J. A. "Naturalistic Case Studies Exploring Social-Cognitive Mechanisms, and Some Methodological Issues in Research on Problems of Teachers." Journal of Research in Science Teaching, Vol. 19, No. 3 (1982), pp. 191-203.

Eggleston, James. Studies of Science Teaching Processes. In Charles P. McFadden (Ed.) World Trends in Science Education, International Symposium, Summer 1979. Atlantic Institute of Education, Halifax, Nova Scotia, 1980, pp. 256-65.

Eggleston, J. F.; Galton, M. J.; and Jones, M. Processes and Products of Science Teaching. Schools Council Research Series. London: MacMillan, 1976.

Evans, Thomas P. Flanders System of Interaction Analysis and Science Teacher Effectiveness. Paper presented at the annual NARST meeting, Minneapolis, Minnesota, March 8, 1970, ERIC ED 059094.

Freilich, Mark B. "A Student Evaluation of Teaching Techniques." Journal of Chemical Education, Vol. 60, No. 3 (March, 1983), pp. 218-21.

French, Peter, and MacLure, Margaret. "Getting the right answer and getting the answer right." Research in Education, No. 22 (November, 1979), pp. 1-23.

Gabel, Dorothy, and Sherwood, Robert. "The effect of Student Manipulation of Molecular Models on Chemistry Achievement according to Piagetian Model." Journal of Research in Science Teaching, Vol. 17, No. 1 (1980), pp. 75-81.

Gabel, Dorothy L., and Sherwood, Robert D. "Facilitating Problem Solving in High School Chemistry." Journal of Research in Science Teaching, Vol. 20, No. 2 (1983), pp. 163-177.

Gallagher, J. J. A Topic Classification System for Classroom Observation. A.E.R.A. Monograph No. 6. Rand McNally: Chicago, 1970.

Gallagher, James J., and Aschner, Mary Jane. "A Preliminary Report On Analysis of Classroom Interaction." Merrill-Palmer Quarterly, Vol. 9 (1963), pp. 183-194.

Gearhart, Maryl, and Newman, Denis. "Learning to Draw a Picture: The Social Context of an Individual Activity." Discourse Processes, 3 (1980), pp. 169-184.

Green, Judith L. Research on Teaching as a Linguistic Process: A State of the Art. In Edmund W. Gordon (Ed.) Review of Research in Education 10. American Educational Research Association, Washington, U.S.A., 1983, pp. 151-251.

Grimshaw, Allen D. "Comprehensive Discourse Analysis: An Instance of professional peer interaction. Lang. Soc., 11 (1982), pp. 15-47.

Grotz, Leonard C. "Learning Problems and Teaching Strategies." Journal of Chemical Education, Vol. 56, No. 1 (January, 1979), p. 7.

Gurwitsch, Aron. The Field of Consciousness. Pittsburg: Duquesne University Press, 1964.

Hacker, R. J. "A Cross-Cultural Study of Science Classroom Interaction." British Journal of Educational Psychology, Vol. 49, pt.1, (1979), pp. 51-59.

Hamilton, David and Delamont, Sara. "Classroom research: a cautionary tale." Research in Education, No. 11 (May, 1974), pp. 1-15.

Hanson, Norwood Russell. Patterns of Discovery. Cambridge, England: Cambridge University Press, 1972.

Hartford, Fred, and Good, Ron. "Training Chemistry Students to Ask Research Questions." Journal of Research in Science Teaching, Vol. 19, No. 7, (1982), pp. 559-70.

Hatch, Evelyn, and Long, Michael H. Discourse Analysis, What's That? In Diane Larsen-Freeman (Ed.) Discourse Analysis in Second Language Research. Rowley, Ma.: Newbury House, 1980, pp. 16-27.

Heritage, J. C. and Watson, D. R. "Aspects of the properties of formulations in natural conversations: some instances analysed. Semiotica, 30, 3/4 (1980), pp. 245-262.

Hermann, G. D., and Hincksman, N. G. "Inductive versus Deductive Approaches in Teaching a Lesson in Chemistry." Journal of Research in Science Teaching, Vol. 15, No. 1 (1978), pp. 37-42.

Herron, M. D. "The Nature of Scientific Enquiry." School Review, Vol. 79 (Feb., 1971), pp. 171-212.

Heyman, Richard. "Clarifying Meaning Through Classroom Talk." Curriculum Inquiry, Vol. 13, No. 1 (1983), pp. 23-42.

Hillman, R. A. H.; Hudson, M. J.; and McLean, I. C. "A Preliminary Study of Some of the Learning and Assessment Difficulties in Connection with O-Level Electrochemistry." School Science Review, Vol. 63, No. 222 (September, 1981), pp. 157-163.

Hirst, Paul H. "What is Teaching." Journal of Curriculum Studies, Vol. 3, No. 1 (May, 1971), pp. 5-18.

Hofstein, Avi, et al. "A Comparative Study of Chemistry Students Perception of the Learning Environment in High School and Vocational School." Journal of Research in Science Teaching, Vol. 17, No. 6 (1980), pp. 547-52.

Hook, Colin M., and Rosenshine, Barak V. "Accuracy of Teacher Reports of Their Classroom Behavior." Review of Education Research, Vol. 49, No. 1 (1979), pp. 1-12.

Hyman, Ronald T. Teaching: Triadic and Dynamic. In Ronald T. Hyman (Ed.) Contemporary Thought on Teaching. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971, p. 63.

Jackson, Philip W. The Way Teaching Is. In Ronald T. Hyman (Ed.) Contemporary Thought on Teaching. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971, pp. 7-8.

Jakobson, Roman. Linguistics and Poetics. In T. A. Sebeok (Ed.) Style in Language. Cambridge: Massachusetts Institute of Technology Press, 1960, p. 352.

Johnson, D. J. "How do Chemistry Teachers Teach?" Education in Chemistry, Vol. 14, No. 4 (July, 1977), pp. 108-109.

Johnstone, A. H., and Percival, F. "Attention Breaks in Lectures." Education in Chemistry, Vol. 13, No. 2 (March, 1976), pp. 49-50.

Kilbourn, Brent. Ethnographic Research and the Improvement of Teaching. In Hugh Munby, Graham Orpwood, and Thomas Russell (Eds.) Seeing Curriculum in a New Light. Toronto: Ontario Institute for Studies in Education, 1980, pp. 162-181.

Kingdon, J. M. and Critchley, W. E. "The Use of Technical Terms in CSE and O-level Chemistry." School Science Review, Vol. 64, No. 227 (December, 1982), pp. 367-72.

Komisar, B. Paul. Teaching: Act and Enterprise. In C.J.B. McMillan and Thomas W. Nelson (Eds.) Concepts of Teaching: Philosophical Essays. Chicago: Rand McNally, 1968, p. 77.

Komisar, B. Paul. Is Teaching Phoney? In Ronald T. Hyman (Ed.) Contemporary Thought on Teaching. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971, p. 59.

Kornhauser, Aleksandra. "Trends in Research in Chemical Education." European Journal of Science Education, Vol. 1, No. 1 (1979), pp. 21-50.

Lagowski, J. J. "For Your Attention Stat." Journal of Chemical Education, Vol. 59, No. 8 (August, 1982), p. 625.

Lazarowitz, R. "Does Use of Curriculum Change Teacher's Attitudes Toward Inquiry?" Journal of Research in Science Teaching, Vol. 13, No. 6 (1976), pp. 547-52.

Lazarowitz, R., and Lee, A. E. "Measuring Inquiry Attitudes of Secondary Science Teachers." Journal of Research in Science Teaching, Vol. 13, No. 5 (1976), pp. 455-60.

Lazonby, J. N.; Morris, Jane E.; and Waddington, D. J. "The Muddlesome Mole." Education in Chemistry, Vol. 19, No. 4 (July, 1982), pp. 109-11.

Lippincott, W. T. "For Students Who Need More: Accommodation with Integrity." Journal of Chemical Education, Vol. 54, No. 6 (June, 1977), p. 331.

Lippincott, W. T. "Why Students Hate Chemistry." Journal of Chemical Education, Vol. 56, No. 1 (January, 1979), p. 1.

Lynch, Michael; Livingston, Eric; and Garfinkel, Harold. Temporal Order in Laboratory Work. In Karen Knorr and Michael Mulkay (Eds.) Analytical Perspective in Social Studies of Science. London: Sage Publications (forthcoming).

McNaught, Carmel. "Relationship between Cognitive Preference and Achievement in Chemistry." Journal of Research in Science Teaching, Vol. 19, No. 2 (1982), pp. 177-86.

McNeill, John. "Introduction to the Concept of Teaching." Department of Ed. P.A., University of Calgary, Calgary, Alberta, Canada, 1983. Personal Communication.

Merritt, Marilyn. "Repeats and Reformulations in Primary Classrooms as Windows of the Nature of Talk Engagement." Discourse Processes, Vol. 5 (1982), pp. 127-145.

Mishler, Elliot G. "Meaning in Context: Is There Any Other Kind?" Harvard Educational Review, Vol. 49, No. 1 (February, 1979), pp. 1-19.

Munby, A. H. "The Use of Three Philosophical Models of Teaching to Analyze Selected Science Lessons." M.A. Thesis, University of Toronto, 1969 (unpublished).

Munby, A. H. "The Provision Made for Selected Intellectual Consequences by Science Teaching: Derivation and Application of an Analytical Scheme." Ph.D. Thesis, University of Toronto, 1973 (unpublished).

Norton, Alfred Dobson. "Classroom Verbal Interaction and Achievement in College Chemistry: An Investigation of Teacher Influence Using Flanders' Method of Interaction Analysis on the Knowledge and Comprehension of Students in College Chemistry." Ph.D. Thesis, N.Y. University, 1970. Dissertation Abstracts International (1971), A.31, pp. 3365-A - 3366-A.

Oakeshott, Michael. Teaching. In Ronald T. Hyman (Ed.) Contemporary Thought on Teaching. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971, pp. 13-14.

Parakh, Jal. S. "A Study of Teacher-Pupil Interaction in High School Biology Classes Pt. I. The Development of a Category System." Journal of Research in Science Teaching, Vol. 6, No. 3 (1969), pp. 284-292.

Parakh, Jal. S. "A Study of Teacher-Pupil Interaction in High School Biology Classes* Part II. Description and Analysis." Journal of Research in Science Teaching, Vol. 5, No. 3 (1967-68), pp. 183-192.

"Piaget takes hold in chemistry education." Chemical and Engineering News (April 4, 1977), pp. 25-26.

Piper, M. K., and Butts, D. P. "The Development and Evaluation of a Televised Science Inservice Program." Journal of Research in Science Teaching, Vol. 13, No. 2 (1976), pp. 177-83.

Powell, Marjorie. "Variable Teaching Behaviours: The Importance of Considering Context in Understanding Teaching." Educational Research Quarterly, Vol. 4, No. 2 (Summer 1979), pp. 36-42.

Power, Colin. "A Critical Review of Science Classroom Interaction Studies." Studies in Science Education, Vol. 4 (1977), p. 1-30.

Ramsey, Gregor Allen. The Development of Chemistry Content by the Teachers of CHEM. Study in High Schools in Franklin County, Ohio, (1969) ERIC ED 041782.

Rist, Ray C. "On the Relations Among Educational Research Paradigms: From Distain to Detente." *Anthropology and Education Quarterly*, Vol. 8 (1977), pp. 42-49.

Roberts, Douglas A., and Russell, Thomas L. "An Alternative Approach to Science Education Research: Drawing from Philosophical Analysis to Examine Practice." *Curriculum Theory Network*, Vol. 5, No. 2 (1975), pp. 107-125.

Rosenshine, Barak, and Furst, Norma. Research on Teacher Performance Criteria. In B. Othanel Smith (Ed.) *Research in Teacher Education*. Englewood Cliffs, N.J.: Prentice-Hall, 1977, p. 44.

Rosenshine, B. and Furst, N. The Use of Direct-Observation to Study Teaching. In R. Travers (Ed.) *A Second Handbook of Research on Teaching*. Rand McNally, 1973, p. 122.

Scheffler, Israel. "Philosophical Models of Teaching." *Harvard Educational Review*, XXXV (Spring, 1965), pp. 131-43.

Scheffler, Israel. Teaching. In Ronald T. Hyman (Ed.) *Contemporary Thought on Teaching*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971, p. 37.

Shavelson, Richard J., and Stern, Paula. "Research on Teachers' Pedagogical Thoughts, Judgements, Decisions, and Behavior." *Review of Educational Research*, Vol. 51, No. 4 (Winter, 1981), pp. 455-498.

Shrigley, R. L. "Credibility of the Elementary Science Methods Course Instructor as perceived by Students: A Model for Attitude Modification." *Journal of Research in Science Teaching*, Vol. 13, No. 5 (1976), pp. 449-53.

Simon, A., and Boyer, E. G. (Eds.). *Mirrors for Behaviour: An Anthology of Classroom Observation Instruments*, (Volumes 1-6; 7-14; and Supplementary Volumes A and B). Philadelphia: Research for Better Schools, 1970.

Simpsons, R. D., and Brown, D. R. "Validating Science Teaching Competencies Using the Delphi Method." *Science Education*, Vol. 61, No. 2 (1977), pp. 209-19.

Smith, B. Othanel. On the Anatomy of Teaching. In Ronald T. Hyman (Ed.) *Contemporary Thought on Teaching*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971, p. 24.

Smith, B. O., and Meux, M. *A Study of the Logic of Teaching*. Research Project 258(7257), U.S. Office of Education: University of Illinois, 1958.

Smith, B. O., and Meus, M. O. *A Study of the Strategies of Teaching*. Bureau of Educational Research. Urbana: Illinois, 1967.

Smith, Mary Lee. "Benefits of Naturalistic Methods in Research in Science Education." Journal of Research in Science Teaching, Vol. 19, No. 8 (1982), pp. 627-638.

Stake, Robert E. "The Case Study Method in Social Inquiry." Educational Research, February, 1978, p. 6.

Stubbs, Michael. Keeping in touch: Some functions of teacher-talk. In M. Stubbs and S. Delamont (Eds.) Explorations in classroom observations. London: Wiley, 1976, pp. 151-172.

Tamir, P. "Classroom Interaction Analysis of High School Biology Classes in Israel." Science Education, Vol. 65, No. 1 (January, 1981), pp. 87-107.

Tisher, R. P. The Nature of Verbal Discourse in Classroom Observation. In W. J. Campbell (Ed.), Scholars in Context: The Effects of Environments in Learning. John Wiley, Australia, 1970.

Toulmin, Stephen Edelston. The Philosophy of Science: An Introduction. New York: Harper and Row Publishers, 1960.

Toulmin, Stephen Edelston. The Uses of Argument. Cambridge, England: Cambridge University Press, 1969.

Walford, Geoffrey. "Do Chemistry Text Books Present a Sex-Biased Image?" Education in Chemistry, Vol. 18, No. 1 (January, 1981), pp. 18-19.

Ward, Charles R., and Herron, J. Dudley. "Helping students understand formal chemical concepts." Journal of Research in Science Teaching, Vol. 17, No. 5 (1980), pp. 387-400.

Whitfield, Richard C. "Educational Research and Science Teaching." School Science Review, Vol. 60 (1979), pp. 411-430.

Wolfson, Morton Louis. "A Consideration of Direct and Indirect Teaching Styles with respect to Achievement and Retention of Learning in Science Classes." Ph.D. Thesis, New York University, 1970. Dissertation Abstracts International (1971), A31, p. 6435-A.

Ziman, John. Public knowledge: An Essay concerning the Social Dimension of Science. Cambridge, England: Cambridge University Press, 1968.

Ziman, John. Reliable knowledge: An exploration of the grounds for belief in science. Cambridge, England: Cambridge University Press, 1978.